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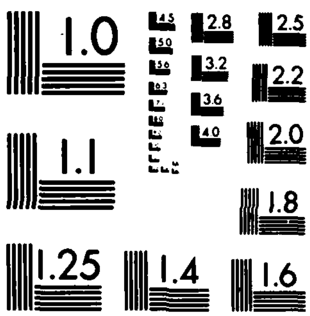

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Presents an overview of the state of the art in water resources planning for projecting future with and without habitat conditions. A survey of the literature and selected planning studies determined the following major issues which are discussed in the report: (a) what environmental changes accompany land use change, (b) how water resources development impacts land use, (c) what concepts and requirements for environmental planning exist, and (d) what techniques are available and are being used to project wildlife futures.

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Based on study findings of existing environmental planning capabilities, the report recommendations describe two approaches for assessing probable future habitat conditions: (a) one for use in conjunction with a habitat evaluation procedure which expresses habitat value as a numerical product of habitat quality and quantity, and (b) one for use in conjunction with a habitat evaluation procedure which expresses habitat value based on land use characteristics.

Report recommendations emphasize that any effort to forecast and evaluate habitat conditions be conducted by professionals in three phases: (a) evaluation of existing habitat and prediction of probable land use changes, (b) interpretation and conversion of predicted probable land uses into expressions that are meaningful in terms of habitat composition, and (c) forecast and evaluation of probable habitat.

ASSESSMENT OF PROBABLE FUTURE LAND USE AND HABITAT CONDITIONS IN WATER RESOURCES PLANNING

by

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PREFACE

This report was produced during the period October 1978 to July 1981 as part of Work Unit 3135 within the Planning Methodologies Research Program. The objective of the work unit was to recommend methods and procedures and to develop concepts for projecting habitat conditions under with and without project alternatives on the basis of interpretation of land use.

The study determined that a best procedure for projecting wildlife futures cannot be detailed because any one procedure would not be appropriate for all planning circumstances. However, an approach framework that would be applicable to essentially all planning efforts involving a projection of wildlife futures is apparent and is described. The final chapter contains strategy recommendations for projecting habitat conditions. Two strategies are presented but no application was performed for either because they are straightforward. The purpose of the framework and the strategies is to provide a guide for developing a statement of the probable wildlife future given the existing conditions, trends, and local preferences, and in recognition of environmental opportunities, restraints, and protection needs.

The reader will note that the report includes a discussion of the requirements of the Corps 200 series regulations for planning. These regulations were rescinded after work on this study was completed. Although the 200 series is no longer required, the discussion is retained because content and objectives of these regulations serve as an excellent source of guidance.

The report includes mention of several habitat evaluation techniques including the two most widely known techniques: the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP), and the Corps' Lower Mississippi Valley Division's Habitat Evaluation System (HES). Although some readers may not be familiar with these techniques, a description of them is not presented as that would be beyond the scope of this report. However, a bibliographic citation for each technique is given for those who wish to learn about the procedural mechanisms.

It should also be noted that the opinions expressed in this report are entirely those of the author and do not necessarily represent the views of the Corps of Engineers.

Information, ideas, and perceptions from many persons in Corps district and division offices were the major source for material. Special thanks is extended to the following individuals who were particularly helpful: Lower Mississippi Valley Division - Tom Holland; North Central Division - Alfred Behm and Dean Eitel; Chicago District - Ed Hanses; Fort Worth District - Melvin Smith; Louisville District - Neal Jenkins and Andrew Miller; Mobile District - Glen Coffee; Sacramento District - Fred Kindel and Bob Verkade; Savannah District - Jim Hardee and Mickey Fountain; St. Louis District - Dan Raglan and John Brady; Walla Walla District - Paul Peloquin and Ray Oligher; and the Wilmington District - Bill Adams and Coleman Long. Thanks is also expressed to Pat Webb of the Hydrologic Engineering Center for his review comments.

SUMMARY

This report is concerned with the concepts and techniques applied to projecting with and without conditions for wildlife in water resources development planning. In that land use is an underlying factor in habitat quality and in that the state of the art for projecting land use is reasonably good, the study's approach to wildlife futures is through land use. The report discusses five major issues of the overall topic: (a) what environmental changes accompany land use change; (b) how water resources development impacts land use; (c) what concepts and requirements for environmental planning exist; (d) what techniques are available and are being used to project wildlife futures; and (e) what recommendations can be made.

Information for the report was compiled from the literature and through contact with Corps field offices. Discussions with environmental planners yielded general descriptions of the approaches taken for forecasting futures, the problems involved, and procedures used for projecting with and without conditions with respect to habitat and biota. Several planning documents were recommended for review,and further information on assumptions, criteria, and methods was extracted from them.

Environmental Response to Land Use Change

Changes in land use may be brought about through natural succession, natural disturbance, or human activity. The environmental response may be noticable or imperceptible, immediate or delayed, temporary or permanent, limited to the site or extended to the surrounding area or even to places far removed. The response may be exhibited by all the plant and animal species or by only a portion. The response may be enhanced or diminished by: the season in which the change occurs, the before and after setting among juxtaposing land uses, the shape of the area, the degree of dissimilarity from the previous land use, and the uniqueness of the area prior to change. The complicating dimensions of response are rooted in four factors of change: rate, duration, magnitude, and area. The environmental response is registered in the alteration of ecosystem characteristics, including:

- the functional ability to fix and cycle energy and conserve and cycle nutrients,
- the structural or spatial arrangement of vegetative cover types,
- the composition and population structure of the inhabiting species, and
- the dynamics of successional patterns.

In turn, alteration of ecosystem characteristics results in alteration of the vegetation and/or the wildlife. Thus, a change in land use alters the diversity of biotic species and their population; the net result of the environmental response is that the environment is different, not necessarily better or worse, but different.

Water Resource Development Impacts on Land Use

This survey did not identify a comprehensive study of land use change and environmental response at any given project,much less for a variety of projects under varying environmental conditions. Nevertheless, based on the literature that is available, several important observations can be made:

a. The patterns of land use and land use change at water resource development projects are not directly dependent on the type of project.

b. Each project is associated with a unique combination of conditions and events that affect the particular patterns of land use that occur over the life of the project.

c. Land use information from project-specific studies cannot be extrapolated beyond the broad, already well-recognized generalities concerning water resource development and land use change.

Collectively, the bottom line on these findings is that the specifics of what happened at one project cannot be directly transferred to describe what will occur at a similar project even if in a similar setting. Such impacts can be indicative, however, of the bounds within which characteristic temporal and spatial land use changes can be anticipated and how they are brought about through alterations in both the socio-economic and natural environments.

The major conclusion of the literature review is that the land use that occurs at a given project is essentially an expression of the balance between the influence of the project on the area and the interplay of forces in the area. Although each project is truly site specific and unique, there is a common framework within which the forces effecting land use change occur: (1) the drivers, or socio-economic factors; (b) the limiters, or natural capability factors; and (c) the products, or land uses.

Concepts and Requirements for Environmental Planning

Project planning and the assessment of probable future conditions include forecasting the wildlife condition. The laws, regulations, and policies regarding wildlife in planning require:

a. that wildlife be given consideration equal to that given to other elements of planning,

b. that there be an anticipation and comparison of impacts by project alternatives,

c. that impacts on resources be quantified wherever possible, and

d. that there be explicit documentation and display of impacts and a record of decisions.

To fulfill these requirements, planning for a water resources development project involves the development of future scenarios for all the with and

without project alternatives. Scenarios are developed from anticipated changes in economic and social conditions and what land use changes these conditions would likely produce within the natural setting of the project. The development of scenarios includes the anticipation of environmental changes, i.e. what the wildlife response would be to the probable future land uses. Within environmental planning, the overall purposes are to minimize the adverse impacts and to promote environmental consonance.

Techniques Available for Projecting Wildlife Futures

A basic constraint or difficulty in anticipating wildlife response is that is is not yet clear what information is needed or how to make the best use of the techniques available. There are three major reasons for this. First, there are deficiencies in understanding land use - habitat - wildlife relationships and ecosystem processes. Second, this study found that during planning, there is usually little coordination between assessments of the natural and the socio-economic environments even though it is through their interaction that the land use and habitat conditions evolve. In conjunction with this oversight, there are planners who become overwhelmed by the uncertainties of forecasting and in effect obstruct themselves from pursuing the objectives of planning. A final problem in forecasting wildlife futures is that the habitat and measurement techniques available for assessing environment response are typically not being applied in a way that is adequate for dealing with a dynamic system in a planning context.

Under the existing state of the art, there are essentially three practical approaches for forecasting wildlife conditions:

1. Extrapolation, i.e. forecast based on the type and extent of impacts that have occurred at a similar type project in a similar setting.

2. Wildlife population census and trend projection.

3. Habitat evaluation.

In reality, current planning studies usually involve some combination of these. A possible fourth approach would be one based on ecosystem function; unfortunately, the state of the art is not well enough developed to permit its applications. Of the three existing approaches, habitat evaluation is the most feasible. In both of the other approaches, the results yield a range of estimate that is either too broad or of too low a level of confidence to be useful. Additional support for habitat evaluation comes from regulations proposed in 1979 by the Departments of the Interior and of Commerce, which specify use of a technique based on habitat evaluation, and from the Water Resources Council 1980 procedures for evaluating environmental quality.

There are three basic problem areas, or at least unappreciated consequences of the way in which habitat evaluation methods are currently applied in forecasting wildlife conditions:

1. The methods are more useful for wildlife management than for planning purposes. This is because they emphasize factors that are measurable under existing conditions and do not give

consideration to how to anticipate them under future conditions.

2. The methods, or the interpretations of their results, tend to treat habitat quality values as if they were a precise dimension even though such values are based on two orders of abstraction (what to measure and what quality can be inferred from the measurements).

3. The methods tend to compound their difficulties by striving for greater exactitude in their measure of habitat quality values.

Recommendations

It is recommended that the forecasting of wildlife futures be approached through interpretation of anticipated probable land uses and land use change. Among the attributes of this approach are that it:

- offers a logical framework for use in planning (in fact, it is already loosely applied by some planners),
- incorporates the evaluation of habitat quality,
- integrates environmental and economic studies, and
- lies within the capabilities of the state of the art for habitat evaluation and land use projection.

It is also recommended that the spatial analysis techniques be used as the format for implementing this approach (or any other). These techniques offer an efficient and effective means for organizing and analyzing geographically distributed data.

The approach framework consists of two phases of effort: the projection of land uses and the interpretation of wildlife condition from projected land uses. Notably, the emphasis is on the phase for which capability is stronger, land use projection. The second phase makes use of the only real clues available and applicable to projecting and analyzing future habitat quality: i.e. (1) the perception and spatial distribution of future land uses and (2) the fact that land use has a role in the utility or suitability of an area for wildlife. The framework makes use of these clues by focusing on those attributes of land use pattern and change that affect the habitat and in turn the wildlife productivity.

Some of the frustration that has been experienced in evaluating and projecting habitat quality using available procedures is due partly to some misplaced optimism in their use and partly to unthinking application of their products. Once the capabilities of these techniques are better appreciated and are better linked to land uses, they can be better applied to planning problems. Chapter VII describes two strategies for applying the recommended framework: one which incorporates habitat evaluation techniques that express habitat value as the numerical product of habitat quality and quantity, and one which incorporates techniques that express habitat value based on land use

characteristics. The second strategy enables the general framework to be more fully developed since it places emphasis on relating habitat quality to factors that are measurable under existing conditions as well as projectable under future conditions.

CHAPTER I

INTRODUCTION

Background

The National Environmental Policy Act (NEPA) of 1969 punctuated the environmental momentum of the 1960's. It provided environmental concerns with a keystone for their organization and intensification and with a point of reference which prefaced a proliferation of environmental groups, businesses, agencies, regulations, guidance, techniques, philosophy, and issues during the 1970's. In conjunction with the closer attention given to construction and development at every level, consideration of fish and wildlife resources associated with Corps Civil Works project planning, construction, and operation came under scrutiny and criticism.

For water resources planning and development, a legal framework has evolved which entails interagency coordination for the promotion of environmental quality and for the conservation and enhancement of fish and wildlife. Clearly however, the legal process has outpaced technological development in responding to issues of environmental concern. Results from procedures for describing fish and wildlife resources under present and project alternative conditions are arguable, yet for lack of real understanding of ecosystem functions and the effects of human influence, it is not anticipated that the approach taken by such procedures will significantly change in the near future (U.S. Army Engineer Institute for Water Resources, 1980).

The projection of future with and without conditions with respect to habitat and biota is one area of water resources development planning that is in need of research for improved techniques. Since project impacts are defined as the difference between the with and without project conditions and since mitigation of adverse impacts must be considered, there is need for the capability to estimate reasonably probable future conditions in order to adequately assess project impacts. Impact analysis is a product of professional judgement compounded by the uncertainties of probable futures and probable wildlife measures in those futures. The analysis could never be devoid of uncertainty but it is believed that impact assessment could be improved by: (1) conscientious documentation of assumptions and techniques used for projecting and interpreting environmental conditions; (2) development of better techniques; and, (3) increased participation and consensus among agencies and the public as to what the probable futures and impacts would be.

Generally, the projection of future conditions is based on economic and demographic forecasts. Land use scenarios which could accommodate these forecasts are developed and consideration is given to anticipating the environmental changes that could occur. While techniques have been developed for reasonably good analysis and projection of land uses, water resources planning lacks the capability for interpreting land use scenarios in terms of wildlife.

Approach and Objective

There is a relationship between water resource development and induced land use change. It has also long been known that there is a relationship between land use change and wildlife population change (Leopold, 1933). For this reason, land use, as used in this study refers to the characteristic surface expression which is a product of the interaction of the human social system and the environmental ecosystem. These surface expressions are variously classified as land use categories. Essentially then, the projection of future wildlife conditions involves the linkages depicted in Figure 1. The work unit of which this report is a product, is based on the premise that the probable future habitat conditions could be projected with more certainty if the relationships between projects and land use, and land use and wildlife were better understood. This report is concerned with the first of these relationships: the land use changes associated with water resources development. A separate effort of the work unit focused on the relationship between land use and wildlife.*

This study of land use assessment in water resources development was undertaken in two tasks: (1) a literature survey on relationships between water resources development projects and project-induced land use changes; and, (2) a survey of procedures used by planners to project future land use and habitat conditions. The overall objective of the study was to provide a better understanding of land use-project relationships both as it has actually occurred and as it is anticipated to occur. The findings of the study were used in preparing recommendations for projecting future with and without habitat conditions.

Literature Survey

The literature survey was concerned with a review of the literature on land uses, land use analysis, and land use changes associated with water resources projects. The objective was to determine if there is enough information in the literature to outline how water resources development impacts on land use in the vicinity of projects and how that impact relates to project size and circumstances of project setting. Included within this objective was the exploration of the possibility that kinds of land use change can be associated with types of projects.

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* The investigation of land use-wildlife relationships was conducted under contract to New England Research, Inc. of Worcester, Massachusetts in two phases: Phase I, literature survey (U.S. Army Engineer Institute for Water Resources 1980); and Phase II, field study, now in review.

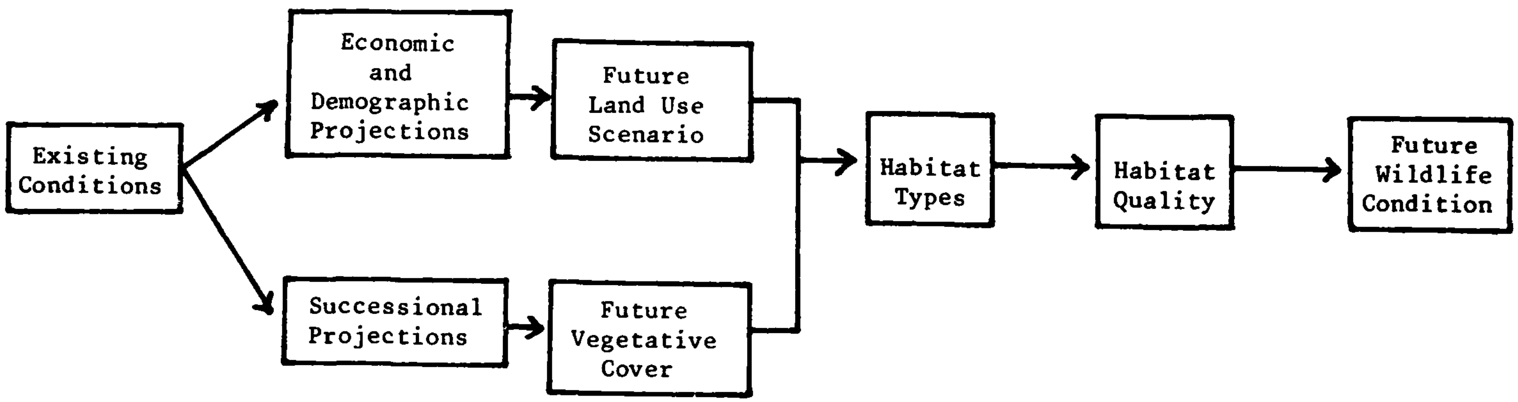

Figure 1. Schematic of approach for projecting wildlife condition.

Procedures Survey

The procedures survey sought to overview what procedures or criteria are used by Corps planners for projecting the with and without project scenarios. Of particular interest was the methodologies for simulating future development, accounting for future condition of wildlife habitat, and estimating project impacts on wildlife.

Report Organization

Chapter II presents a theoretical discussion of land use change and resultant environmental change. The ideas contained in this discussion were developed during the progress of the work unit. Although these ideas may not have practical application and may be contrary to concepts held by others, they are included because they provide a preface for the rest of the report. In contrast to Chapter II, Chapter III provides a discussion of the actual changes that have accompanied water resource development. Chapter III then presents the findings of the literature survey task.

Moving on from land use change, the next three chapters are concerned with land use analysis and forecasting. Chapter IV focuses on the theory and concepts while Chapter V reviews the requirements and guidance in environmental planning. Chapter VI discusses techniques that are actually being used by planners; i.e., the findings of the procedures survey task, Chapter VI also presents an overview of procedures that were identified in the literature but that may not be in use. Finally, Chapter VII contains the recommendations.

CHAPTER II

THEORETICAL LAND USE CHANGE AND ENVIRONMENTAL RESPONSE

General Concepts

The land use changes and the environment responds. This relationship appears to be simple and very likely it has been observed by nearly everyone. The importance of the relationship is also clear since it is the ultimate concern behind environmental legislation, yet, however obvious and important the relationship may be, it is definitely not simple. A change in land use may occur quickly or gradually; it may be brought about by nature or by man; it may occur at one small site or over a large area. The environmental response may be noticeable or imperceptible, immediate or delayed, temporary or permanent; it may be limited to the area in which the land use change occurred, it may extend to the surrounding area, or it may even be effected in places far removed; it may be a total realization or it may be exibited by only a portion of the plant and animal species; it may be enhanced or diminished by virtue of the season, the before and after settings among juxtaposing land uses, the shape of the area over which the change occurred, the degree of dissimilarity from the previous land use, and the uniqueness of the area prior to change.

Rate, duration, magnitude, and area are among the factors that complicate the relationship between a change in land use and the ensuing environmental response. In the physical and engineering sciences such terms can be quantified and manipulated in formulas in order to analyze or model a variety of real or imagined conditions. Magic numbers elude the environmental analyst though, whether he is trying to ascertain the impact of land use changes that have occurred or that are projected to occur. There are at least two good reasons why this is so. First, land use and environmental considerations cannot be separated: while the land use is conducive to the environmental character, the environment is characterized by the land use. Second, the environmental mechanics or ecosystem processes are not understood. While it is recognized that a holistic approach is needed, procedures for implementing such an approach have not been identified. There is a wealth of literature written from many different perspectives (e.g. preservationists, conservationists, doomsday prophets, and resource and construction agencies), all of whom emphatically urge that this or that _must_ be done, but fall short of suggesting _how_.

Perception of Land Use Change

Despite the complicating circumstances, change and response do not occur haphazardly. This enables a rational approach to the problem. There are three mechanisms which are responsible for land use change and which may interact: natural succession, natural cataclysmic disturbance, and human activity. Of the three, natural disturbance is the most unpredictable although the relative likelihood that a particular area will experience certain types of major storms and earth movements can be estimated.

Cataclysmic events aside, for any given area, a finite array of land uses to which the area could convert can be listed, and the likely nature of the response can be anticipated at least in a general way. For example, natural succession, the orderly progression of ecologic stages is recognized. Areas dominated by man's activities frequently undergo change analogous to succession: for example, farm land may become residential and then commercial, but industrial would not become agricultural. Further, natural areas likely to be converted to a man-dominated use can be identified: for example, an easily accessible bottomland forest would be cleared for agricultural purposes before an upland forest would, while a hilly rocky area may never realize intensive human use except for recreation. Thus, natural succession, developmental succession, and coincidence of site characteristics with the specific requirements for man's use provide at least conceptual understanding of land use change:

> "Understanding is based on abstraction. Phenomenon are often intricate and obscure - significant relationships are detected, embodied in concepts, related to one another, and tested and revised in the systems of abstraction that are science." (Whittaker, 1973)

Perception of Response

There is no ecosystem that has completely escaped influence from man even though man has not imposed his patterns of activity on every location. Ecologically, the response to human activity is keyed to the manifestation of that activity, the land use. The combination of intensity, quantity, variety, magnitude, and frequency of human activity in space and time is evidenced in the land use pattern and is significant in affecting the ecosystem function, structure, composition, and dynamics (Franklin, 1978). The environmental response to land use change then is represented in an alteration of these ecosystem characteristics:

a. functional ability to fix and cycle energy and conserve and cycle nutrients;

b. structure or spatial arrangement of the vegetative cover types;

c. composition and population structure of the inhabiting species i.e. the number of species and their relative abundance, and the densities and the age and size-class distributions of individual species;

d. dynamics of successional patterns.

Directly or indirectly, land use change involves vegetation change and wildlife change; it is the effect on these two components that solicits the environmental response or ecosystem alteration. Keyes' (1976) listing of the several ways by which urban land development impacts on vegetation and wildlife highlights the factors in ecosystem alteration. The listing may be summarized as: removal, pervasion, reduction, and introduction of habitat

types; infringement, interference, and encroachment of species activities; elimination and introduction of predators; introduction, depletion, management, elimination, and encouragement of individual species; and the cumulative effects of urban pollution, presence, and noise.

Monitoring Change and Response

The preceding sections have tried to develop the concept of land use as a function of two inseparable systems, the social-economic environment and the natural environment. In this concept land use change is brought about through a modification in at least one of these systems. Naturally, man has become interested in land use change: he is innately curious and ordered and therefore intent on analyzing, classifying, and manipulating his world. A further incentive to this interest is man's realization that his well-being affects and is affected by land use. Along with this realization man has begun to exhibit responsibility and guilt for his actions, as is evidenced by environmental legislation, agencies, and groups.

There are relatively few places where land use changes can be satisfactorily documented. Historical aerial photography provides the best data source, but the quality and suitability of data is dependent upon the dates, and the comparability of altitude, areal coverage, and type of photography for each date. Even when land use change can be documented, conclusive assessment of how and to what extent that change has affected wildlife populations is not possible. First of all, historical wildlife population data which has been consistently and regularly obtained for an area over a period of even a few years is practically nonexistent. Second, even if a comprehensive historical data base were available, there is no means available for its efficient use since it is not yet clear what the significant parameters are or how they function. As documented by the U.S. Army Engineer Institute for Water Resources (1980), the level of understanding of relationships among wildlife, habitat, and land use is poorly developed. For now, as well as for the foreseeable future, it appears that the approach to describing these relationships is contained in habitat evaluation methodologies; however, since none has been consistently applied at the same area for a period years, their value for monitoring changes in habitat and wildlife is unknown.

In the absence of: (a) documentation of change and response; and, (b) knowledge of what critical factors and relationships are involved, abstract descriptions of ecological systems have been developed. These abstractions are often debated in the literature, but nevertheless they do provide a conceptual framework from which environmental response can be approached. Thus, there are definitions of environmental resilience and stability and there are discussions of how levels of diversity and density of environmental elements can be indicative of how resilient and stable an ecosystem is. (Holling, 1973 and 1978; Odum, 1971 and 1975; Orians, 1975.) Essentially, the intent is to provide a capability for estimating, in a relative way, how vulnerable an area is to change, how drastic the change would be, and how an area might be manipulated so as to accommodate change in the least ecologically damaging way. The conceptual framework in the ecological literature

then has application for projecting future conditions and for managing resources. The main points of the framework and some concepts for its application are discussed in the following paragraphs.

Generally, it is considered that diversity is desirable: that an area with a diversity of habitat types will support a greater diversity of wildlife species and will be better able to absorb the stress of change than would an area of little or no diversity of habitat. It is also considered desirable to maintain an equilibrium: this puts emphasis on the continued existence of the elements, including the species of an environmental system, and also helps guide mitigation planning in that the objective of mitigation is to replace (in-kind) or make-up (out-of-kind) the environmental loss incurred by a project. However, even though stability may be associated with diversity, the relationship is not a simple case of cause and effect, because of the variation of energy inputs and resource flows in an ecosystem (Odum, 1975). For this reason, diversity indices may not be useful for monitoring the impact of change: depending on ecosystem energetics a perturbation may either increase or decrease diversity. Further, attempts to increase stability by maintaining an equilibrium status could actually increase the chances for extinction of a species (Holling, 1973). For example, the ecosystem relationships that a species is exposed to under project conditions may be sufficiently different from the without-project conditions that mitigation by management to maintain the species at without-project population levels would result in increased vulnerability of that species to any additional stress.

When an ecosystem is impacted by a cataclysmic event or is suddenly altered by man, considerable attention and concern may be given to the environmental response. Under these circumstances, a change in species composition and abundance is readily evident. Yet an ecosystem need not be disturbed to undergo change: continuous change, however imperceptible is characteristic of ecosystems as populations fluctuate and natural succession progresses. Because of the constant state of flux, little meaning is attached to a single wildlife population census. When additional censuses are conducted, the data becomes meaningful because there is a basis for comparision: the figures obtained at different points in time can be statistically analyzed and interpreted.

While population data can be significant in indicating changes, it is not a truly accurate monitoring tool because of the limitations of sampling and census methods. The species selected, the sites selected, the sampling design, the equipment, etc., all affect the results which may be further affected by the interpretation put on them. As inadequate as plant and animal population studies may be in actually characterizing population dynamics, they have practically no application for characterizing what the conceptual framework for environmental change and response has shown to be important: the ecosystem energetics. As Eberhardt (1976) points out: "Since all sorts of changes from year to year are inevitably associated with natural populations, any design based solely on population studies may succeed in demonstrating 'statistically significant' changes while failing to answer the crucial question - can these changes be attributed to an 'impact'?"

Although the effect on community dynamics are what should be the concern in monitoring project impact, the traditionally collected data do not translate information. For example, species-diversity indices, ordination measurements, species-abundance curves, and taxonomic inventories do not provide clues to ecological mechanisms. There is general agreement in the literature that these data are not useful indicators, but there are few statements as to what should be monitored. Cooper (1975) identifies three physical characteristics that are indicative of the ability of the biological community to effectively withstand external perturbation:

a. Distribution of the mean generation times of the species composing the community;

b. Dependency on dormant structures (a measure of resiliency); and,

c. Patchiness.

However, his discussion does not suggest how these characteristics should be measured or if they have been useful in discerning ecological impact.

Significance of Change and Response

The Paradox of Significance

The conceptual framework of ecosystem behavior indicates that system energetics and relationships are more significant than the diversity and quantity of system elements, particularly when the system is affected by external change. Typically, however, change and response is monitored by measures of change in the system elements since changes in these elements are what is most readily evident and what provokes public concern. This outlines the paradox in the significance of change and response: what is quantitatively evident may not be biologically significant, yet what is biologically significant may not be evident or quantifiable.

The paradox is mirrored in the implementation of the national environmental policy: for example, the environmental laws and regulation encourage, wherever possible, quantitative statements of impacts to wildlife, but there are several critical concerns in complying with the legal requirements.

a. First, while identification of the quantity of wildlife loss and replacement of that quantity may satisfy the legal requirements, does it really fulfill the objectives of NEPA; i.e. are the measures being quantified indicative of what is significant in the ecosystem?

b. Second, although the regulations call for procedures that yield quantitative measures of anticipated response to project actions, procedures that satisfactorily comply with the regulations are not

available. There are procedures which yield numerical results in terms of such measures as index values, habitat units, and habitat acres, but what is the ecological or even biological significance of these synthetic measures?

c. Third, even if a condition can be measured, it does not necessarily follow that the measured quantity is significant; e.g. individual members of a population can be counted, but a population census is not an accurate count of the members and even if it were, little useful information is conveyed by a single census.

Although it may not be possible to quantify what is biologically significant or to know what is biologically significant about a change in some quantity, nevertheless, more credence is generally given to quantitative expressions. Furthermore, in cases of environmental litigation, quantitative evidence is easier to present and uphold. If requirements for environmental analysis are not somewhat quantitative, then, what standard is there, how could it be demonstrated that an adequate environmental assessment has actually been conducted.

Judging the Response to Change

Unquestionably, a water resources development project changes an area. No matter what type of project, for what purpose, or how large, there will be spatial and temporal changes and there will be environmental responses to those changes. Collectively these are indicative of the project impact and attract a great deal of concern because the overall impact is popularly judged an environmental tragedy. The concern focuses on the acres of terrestrial habitat and miles of riparian habitat that are inundated or otherwise identified as forever lost.

There is an alternative view of project impact; rather than writing it off as an environmental loss it could be considered as an environmental change. This is a broader view, which recognizes the realities that determining what constitutes environmental damage (much less measuring its extent) are beyond present capabilities. The view assumes that environmentally, the impact of a project consists of identifiable and unknown losses and gains and that the proportion of the impact which represents the losses varies. Hypothetically then, it is possible that for some projects the loss would be proportionately less than the gain. The alternative view then allows for the possibility that overall, the condition for wildlife might actually be better after a project then it was before, and further, that this could happen even though the pre- and post-project conditions were very different and the identifiable losses were significant.

It would be extremely difficult if not impossible to prove that a project has resulted in improved conditions; however, such a situation is conceivable simply because of the restrictions on land uses and activities on project lands. The likelihood of the post-project condition being an improvement,

then, would increase as the proportion of land area within the total project area increases;* the likelihood would be further increased on projects where habitat development or management measures are in effect.

Although the issue of project impact focuses almost exclusively on environmental damage, the broader perspective that views project impact as environmental change would be more appropriate to our limited understanding of ecology and to our national policy. It could also be more effective in minimizing damage to the environment since it is not constrained by the requirements of mitigation policy.

The essence of the current view is that the loss of natural space is equated with loss of wildlife and there is intense pressure to mitigate for that loss. However, for reasons outlined in the following points, achieving mitigation is not that simple either during project planning or operation:

a. First, the actual loss cannot be determined.

In general, because population sampling techniques are relatively crude and wildlife populations fluctuate, the size of a population can only be roughly approximated. Estimates based on carrying capacity (actual or potential) or habitat value are also fairly gross because they reflect the limitations of perceiving what the critical ecological factors and interrelationships are. If the population is not known, how can the loss which has occurred or may be expected to occur be calculated?

However, even if the populations were known, there is still another difficulty in figuring the loss, i.e. how to identify the extent of the loss that is due to the project. In assessing project impact, several questions arise for which real answers cannot be given. What are the direct and indirect impacts? What are the primary and secondary impacts? What are the local, regional, and national impacts? The answers can only be estimates and generally can be given no more precisely than descriptive expression of relative trend. While changes in acres and miles can be measured, the impact to wildlife resulting from those changes cannot: the inundation of X acres which supports a known population of X deer does not necessarily mean that X deer will be lost, a 20 percent loss of X habitat does not necessarily mean a 20 percent loss of the resident wildlife populations. It can be assumed that the wildlife of an impacted habitat will be affected, but the extent of that effect is a function of the interrelationships among many spatial and temporal factors in addition to the actual physical alterations of project construction.

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* A study conducted for the Corps by the Coastal Zone Resources Corporation (1975), found that the ratio of manageable resource lands to shoreline miles is useful for grouping impoundment projects and studying their characteristics and problems.

b. Similarly, it is not possible to determine with certainty the amount of mitigation needed, the measures which could fulfull that need, and if or when mitigation is achieved.

c. Further, while the environmental damage caused by a project should not be overlooked or minimized, the priority emphasis on mitigating unavoidable losses through in-kind replacement on proximate lands can mean that other opportunities for benefiting the environment are not pursued or that mitigation is delayed indefinitely.

The alternative view is a realistic recognition of the present limited capabilities for understanding and manipulating ecosystem relationships. This view permits an approach to project impact that could permit a more satisfactory realization of mitigation. It recognizes that the environment cannot remain untouched by man, that certain of man's activities will irrevocably damage the environment, but also that man does have responsibilities for seeking means to conduct his activities in the least damaging way and for developing techniques that, in effect, assist the environmental system. This approach to project impact is more consistent with the national policy as stated in NEPA, to "encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man;...."

CHAPTER III

RECOGNIZED RELATIONSHIPS BETWEEN WATER RESOURCES DEVELOPMENT AND LAND USE

Types of Projects and Their Impacts

Water resources development encompasses the range of activities and structures that are implemented in order to realize improved use of or protection from water bodies and their natural fluctuation. Broadly, there are three types of water resources development projects: navigation projects, flood control projects, and beach erosion control projects. The purposes and measures employed for each type are shown in Table 1. As acknowledged in the four accounts of the Principles and Standards for Water Resources Planning, a project affects both immediate and far-reaching aspects of the quality of life: National Economic Development, Environmental Quality, Regional Development, and Other Social Effects (Water Resources Council 1973, 1980a and b).

The specific effects of a project, including resultant land use changes, can frequently be related directly to the project purpose: e.g., an irrigation project impacts the soils and agricultural activities, a hydropower project impacts the economy and land development. However, the relationship between project and impacts is not always direct: because other factors such as economic, social, and geomorphic characteristics are at work, a given type of project does not have the same impact or result in a consistent pattern of land use and land use change. In a conceptual sense, the project interaction with its setting yields the impacts, which are broadly indicated in the land usage both on and off project lands (Figure 2).

This chapter presents the major findings on project impacts that are reported in the literature. There are many additional publications on the subject that are not covered here either because of their limited scope or because of their repeated recognition of the broad, already-established relationships. Many of these publications are included in an annotated bibliography prepared by the Portland District (1976) on the social and land use impacts of water resource development.

Approaches Taken in the Literature

The literature directly concerned with relationships between water resources development and land use is limited. The review identified 35 references with useful information. Basically, these references either address impacts from individual projects or else compare and try to explain differences in a specific impact (e.g., residential development) from a few projects of the same structural type (e.g., reservoirs).

Table 1

<u>Types of Water Resources Development Projects and Associated Purposes and Measures</u>

Project Type	General Purpose	Incidental Purpose	Measures
Navigation	Aid development and conduct of waterborne commerce	Recreation	Coastal: channels, anchorages harbors, breakwater, jetties Inland: deepening and widening, locks and dams
Flood Control	Regulate floodflows and prevent flood damage	Hydropower Recreation Irrigation Low flow augmentation Navigation Water conservation Water supply Water sedimentation Water quality Fish and wildlife	Dams and lakes, levees and floodwall Channel works, Watershed treatment, Flood plain evacuation and zoning, Appropriate agricultural practices Ditching
Beach Erosion Control	Prevent damage to beaches and shoreline properties	Recreation	Bulkheads, Seawalls, Revetments, Groins, Artificial beach nourishment, Dune vegetation

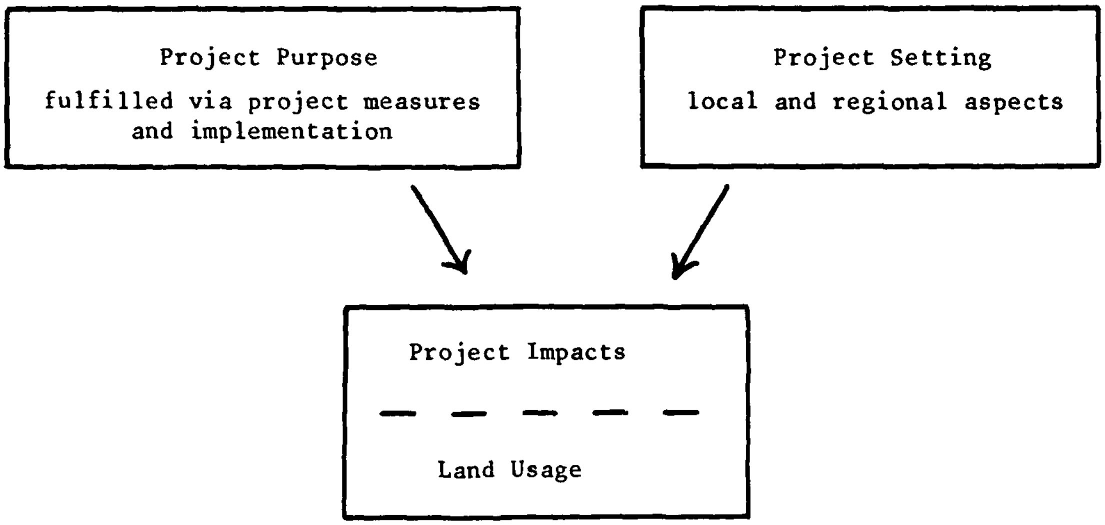


Figure 2. Conceptual view of relationship between type of project and the impact.

Most of the literature is specific to a particular project and the particular interrelationship of factors at that project. The information from project-specific studies cannot be easily extrapolated beyond the broad, already well-recognized generalities concerning water resources development and land use (e.g., flood control may allow industrial development in previously flood-prone areas). The literature that has dealt with more than one project has generally taken the project-purpose approach to try to define relationships between types of projects and types of land use. The relationships drawn from this approach are also fairly general because the factors were found to be so interrelated that their relative significance could not be separated and identified.

The pertinent literature was examined in order to identify factors that have been significant in spatial and temporal project effects on land use. An understanding of the role of these factors has application in water resources planning tasks concerned with the projection of futures.

Findings Reported in the Literature

The literature relevant to project-land use relationships addresses project effects on hydrology, land use, land value, vegetation, fish and wildlife, soils, recreation, navigation, water quality, economics, power, energy consumption, society, and cultural resources. Some of these aspects are given little coverage in the literature and there is no one study that has undertaken a comprehensive investigation of the impact of a project on all these aspects. This discussion of literature findings then is organized by the broadest though still somewhat overlapping, categories of impact topics: the socio-economic environment and the natural environment. In addition, the discussion includes findings relative to the spatial and temporal impacts of projects.

Impacts on the Socio-economic Environment

The socio-economic environment encompasses those aspects in which human activities are predominant. The nature and intensity of human activity is evidenced in the types and patterns of development. Some understanding of the factors that operate in project-induced development can be gained from the literature.

Nearly every publication on the subject of project effects refers to Knetsch (1964). That pioneer study of TVA reservoir impacts on land values used multiple regression analysis to show that values were related to distance from reservoir, topography, urban proximity (a complex variable which took into account several economic and social factors), value of improvements per acre, and per acre cost of development. By contrast, in non-reservoir areas, Knetsch found that land values were dependent on the proportion of the land cleared, road frontage, urban value, and value of improvements.

Prebble (1969) studied land use changes associated with the development that was actually induced by the reservoir. In an attempt to confine his study to land development that was actually induced by the reservoir, he selected a large (50,250 acres at maximum power pool) project in an isolated area (southern Kentucky). He examined three sets of aerial photography to investigate post-project spatial changes over a 16-year period in four types of land use (agricultural, residential, commercial, and public), and compared them with one pre-project set of photography. Applying analysis of variance and multiple regression, the following hypotheses were tested: the effects of relative location around the reservoir, the effects of relative location on a peninsula, and effects of road access. Throughout the study period, agriculture remained the dominant land use, but residential use experienced the greatest increase (more than 20-fold). The key factors encouraging development were identified as:

a. Nearness to a population center.
b. Slopes less 20 percent grade.
c. Road access.
d. View of the lake.
e. Availability of large tracts for development.

Prebble also noted that the factors affecting land use changes had different effects at different times during the course of the reservoir's development.

Residential Development. In a study of residential development at 74 multi-purpose reservoirs, Burby et al. (1970) analyzed data collected at one point in time but which was representative of a cross-section of development factors.

The study found evidence that the existing variation in residential development associated with these projects was a function of aspects related to:

a. The size of the project (length of shoreline).
b. The number and affluence of people within 25 miles (total number of families with incomes of $25,000 or more).
c. The visual attractiveness of the sites.
d. Proximity to an interstate (percent of shoreline within five miles of interstate).
e. Proximity to other reservoirs (combined surface area of reservoirs within 75 miles).

Both univariate and stepwise regression analysis was applied to discern what characteristics influence residential use. Characteristics considered to be potentially significant in the magnitude and density of residential development were identified and grouped by category of influence, i.e. project characteristics, reservoir area characteristics, and reservoir region characteristics (Table 2). The significant findings relative to particular characteristics are also indicated on Table 2.

Table 2

Key Factors Influencing Residential Development in Reservoir Areas
(After Burby et al., 1970)

Category of Influence and Significant Characteristics	Significance of Association with Shoreline Development: All Reservoirs		CE Reservoirs	
	Number of Dwellings	Dwelling Density	Number of Dwellings	Dwelling Density
Project:				
Project size	+	0	+	0
Water Surface	+	0	+	0
Acreage above full pool	+	0	+	0
Shoreline length	+	0	+	0
Percent shoreline acquired by reservoir owner	0	0	0	0
Annual drawdown	0	0	0	0
Summer drawdown	0	0	0	0
Reservoir Area:				
Attractiveness index	+	0	+	+
Topography index	0	0	0	0
Soil index	0	0	0	0
Percent of shoreline within 1 mile of public road	0	0	0	0
Percent of shoreline within 5 miles of U.S. highway	0	0	0	0
Percent of shoreline within 5 miles of interstate	0	+	0	0
Distance to nearest SMSA	—	0	—	—
Total population within 25 miles of reservoir	+	0	+	+
Total SMSA population within 25 miles of reservoir	+	0	0	+
Total families with incomes of $10,000 or more within 25 miles of reservoir	+	0	+	+
Reservoir Region:				
Total population within 75 miles	0	0	0	0
Total SMSA population within 75 miles	0	0	+	+
Total families with incomes of $10,000 or more within 75 miles of reservoir	0	0	+	+
Total surface area of all reservoirs within 75 miles	0	0	0	0

NOTE: 0 = little or no significant
+ = significant positive association
— = significant negative association

In general, Burby et al. found that none of the project characteristics had a systematic influence on the density of shoreline development. For reservoir area characteristics, the association with residential development was found to vary by type of reservoir owner. For example, attractiveness and population were significant at Corps of Engineers reservoirs but not at private power or TVA reservoirs. It was evident that accessibility to highways was not relevant in inducing development unless coupled with sizable populations. Finally, except for Corps of Engineers reservoirs, the reservoir region population characteristics and presence of other reservoirs in the region had little significant effect on shoreline development.

Because the regression analysis indicated that reservoir ownership was important in shoreline residential development, Burby et al. took the analysis further and isolated the study characteristics which were of primary and secondary relative importance in predicting development at Corps reservoirs:

Relative Importance	No. of Dwellings	Dwelling Density
Primary, i.e., Highly Significant Influence	• Total families with incomes of $10,000 or more within 25 miles of reservoir	• SMSA population within 25 miles of reservoir • Acreage above full pool • Shoreline length
Secondary, i.e. Significant influence	• Total families with incomes of $10,000 or more within 25 miles of reservoir	• None

Having identified some key factors influencing residential development in reservoir areas, Burby et al. (1971) conducted another study to investigate the variability in relative importance of certain factors with respect to distance of development from shoreline. In this study, the factors were less general and only three reservoir projects, each under a different type of ownership were studied. Based on multiple regression analysis, the key factors influencing development in the shoreline area (within 300 feet of the shoreline) and in the surrounding area (between 300 feet and 2 1/2 miles of the shoreline) at each of the three reservoirs were identified. For both locational areas, the number of factors important in development and the relative ranking of their importance varied greatly among the reservoirs; however, the quality and availability of public roads and water systems appeared to be more significant than reservoir related characteristics such as view and peninsula location. The ranking of development factors important at the Corps reservoir (Lake Lanier, Georgia) are given in Table 3.

Table 3

Factors Influencing Residential Development in Shoreline and Surrounding Areas at a Corps of Engineers Reservoir: Lake Lanier, Georgia
(After Burby et al., 1971)

	Influencing Factors	
Relative Ranking of Factor	Shoreline Area (within 300 ft. of Shorelin)	Surrounding Area (300 ft-2 1/2 miles from shoreline)
1	Change in quality of public road	Quality of available public road
2	Quality of available public road	Availability of public or community water system
3	Road distance to nearest major urban center	Change in availability of water system
4	Change in availability of water system	Availability of sewer
5	Peninsula location	Ground cover
6	Access to reservoir reservation	View of reservoir
7	Aerial distance from reservoir reservation to shoreline	Aerial distance to nearest public road
8	Availability of sewer system	Accessibility to employment
9	Change in availability of sewer system	Change in quality of public road
10	———	Road distance to nearest major urban center
11	———	Road distance to nearest launch ramp
12	———	Topography
13	———	Distance to nearest elementary school
14	———	Change in aerial distance to public road

In yet another study of residential development in reservoir areas, Burby et al. (1972) simulated residential location patterns through a randomizing procedure in which dwellings were assigned to sites in the shoreline area and the surrounding area on the basis of: (a) supply of land available, and, (b) attractiveness for residence. The study necessarily had to include a description of the sequence of development that land passes through and a delineation of the key decisions and decisionmakers in each development state.

In their 1972 study, Burby et al. concluded that the shoreline area and the surrounding area present two clearly different markets in which different factors affect the attractiveness for development. In the shoreline area, residential attraction was most influenced by access to recreational facilities; physical constraints (such as topography) and access to business and urban centers had little influence. In the surrounding area, attractiveness for residential use was determined by: gentle topography and lack of ground cover; access to roads, work, and schools; availability of utilities, and access to central business district and urban centers.

A major conclusion of the 1972 study by Burby et al. was that the factors which influence the attractiveness for residential development vary from reservoir to reservoir. Burby et al., pointed out that differences in topographic character, pattern of urbanization at the time of impoundment, and reservoir owner and local policy measures appeared to provide the underlying context for the particular combination of development attractiveness factors operating at a given reservoir.

Economic Development. Hargrove (1971) also studied southeastern reservoirs and their effect on development in their surrounding areas. Although he investigated economic and industrial growth rather than residential development, his overall conclusion agreed with that of Burby et al. (1972): that the set of factors affecting growth in a reservoir area differs with the individual reservoir.

In addressing the question "do reservoirs influence development," Hargrove also considered the further issues of what processes are involved in reservoir-induced development and what limits the ability of a reservoir to influence development. The analysis resulted in the construction of a theoretical model for the location of economic development. In overview, the model indicated that:

"The spatial pattern of economic development is the aggregate of location decisions by many individual economic units, each motivated to maximize its own profit. The profit potential of any given site is a function of many factors. Reservoirs affect the development of contiguous areas through modification of the area's preexisting configuration of location factors." (Hargrove, 1971)

Acknowledging that reservoirs do influence development and that this influence may be expected to vary from project to project depending on the relative success that a project has in contributing to the development potential of an area, Hargrove went on to consider the problem of anticipating reservoir-induced changes. The study approach to this problem was by way of considering what changes reservoir development is likely to have on the preexisting location factors (Table 4).

Hargrove hypothesizes that the extent of a given reservoir's effect on development is a function of the characteristics of the area; this idea appears to be supported by emperical evidence. For example, areas contiguous to projects which are isolated, have poor land, have poor transporation systems, or rough terrain, and experience less development than areas having a more favorable set of location factors. Burby et al.'s (1972) findings that: (a) road accessibility is not a significant factor in residental growth unless accompanied by the presence of large populations in the area; and (b) that different factors operate in the contiguous and surrounding areas also agree with Hargrove.

The results of the Hargrove study have application in the planning activity concerned with anticipating the future with project condition:

> "The most likely prediction is that the individual projects would show a great deal of diversity in the degree of development in the contiguous areas. This diversity would derive from the inability of reservoir projects to affect all the relevant location factors and the heterogeneity in the availability of these factors among reservoir locations." (Hargrove, 1971).

Thus, while water resources development may be critical to the economic development of some areas, water resources projects in themselves are rarely, if ever the cause of economic development.

Oyen and Barnard (1975) examined the changes in agricultural land use and then estimated benefits resulting from land use change that occurred after Coralville Dam (Iowa River) was built. The study identified seven factors as being influential in a farmer's decision to bring flood plain acreage into crop production: (1) the expected revenue; (2) additional operating costs; (3) the cost of clearing and draining; (4) the rate of interest; (5) the amount available for conversion; and, (6) the farmer's age. Applying regression model analysis, the study determined that the following variables explain the land use changes observed at Coralville:

Positive influence on probability of conversion to cropland:

- -- increased number of acres available for conversion
- -- increased age of the landowner
- -- increased years of education of the landowner

Table 4

Potential Impacts of Reservoir Development on Industrial Growth Factors
(After Hargrove, 1971)

Reservoir Function (direct and indirect)	Locational Decision Factor Affected	Example of General Effect on Locational Factor
Flow stabilization and regulation (direct)	Flood hazard Water supply Water quality	Improves industrial potential of downstream areas by displacing former uses (e.g., farming, range, or forest uses) and providing flood plain land with reduced flood hazard, dependable water supply, and improved water quality. Impact on industrial development greatest where non-reservoir related factors favor industrial location.
Electric power (direct)	Availability of electric power Cost of electric power	Improves industrial potential over a large region since hydropower can be inexpensively transmitted over long distance.
Navigation (direct)	Availability of navigable waterways	Primarily encourages industrial development in contiguous area by providing locks for vessel by-pass and a connection to a large waterway system. Secondarily can impact on economic haul distances.
Labor (indirect)	Supply of skilled labor	Local labor force may require additional skills during project construction. Local labor force may increase if reservoir right-of-way reduces/removes existing sources of employment.
Aesthetic Factors (indirect)	Recreational opportunity Fish and wildlife augmentation	Impacts potential for residential development, restaurant and shopping facilities, local market supporting recreational needs.
Community Attitudes (indirect)	Attitude toward industry	Impacts community willingness to promote and accept industrial development.

Negative influence on probability of conversion to cropland:

-- increased distance from the dam
-- increased number of acres farmed

In another 1975 study of land use changes and economic benefits of change, Mattson examined the effects associated with the small watershed program and compared observed changes with those predicted to occur. The study included 60 projects in three regions: the southeast, the Mississippi Delta, and the Missouri River tributaries. The land use types considered were cropland, grassland, idle (or transitional), reservoirs, forest, urban, rural/urban (farms and small villages), and miscellaneous.

Regional differences were noted but the significance of the study resulted from the finding that actual post-project land use changes were different from those changes anticipated. In projecting changes, planners had considered three major factors:

1. Land use capability and soil productivity.
2. Farmer's intentions.
3. Relative productivity of land in different uses.

The Mattson study demonstrated that certain additional factors require consideration:

1. Available capital and labor.
2. Trends in farm size and organization.
3. Growth in off-farm labor opportunities.
4. Long-term demands for crops suited to local soils.
5. Institutional controls.

Perhaps the most comprehensive discussion on the relationship between water resources development and land use is given in Hecock and Rooney (1976). Although the study focuses on the changes occurring over a 12-year period at Keystone Reservoir (a Corps reservoir in Oklahoma), it also postulates a general model of land use change associated with reservoirs. A listing of factors that Hecock and Rooney considered to have importance in reservoir-associated land use change is given in Table 5. Their hypothesized model (shown as Table 6) is useful for conceptualizing and analyzing the effects of reservoir development on land use patterns. The model is based on the recognition of zones of impact in which the influence of the reservoir decreases as the distance from it increases.

Hecock and Rooney also highlight the temporal aspects of change. During the construction period, changes, i.e. both losses and gains in land use types, are greatest as is the dispersion of intensive land uses. The post-construction period is marked by greater stability and general increase in urban development. The temporal changes with respect to distance from the reservoir are indicated on Table 6. These authors report that reservoir-induced land use changes occur most visibly in the impoundment area and on those lands immediately adjacent to the impoundment. They also note that

Table 5

Factors Which Have Been Found to be, or are Suspected to be, Important in Influencing the Nature, the Extent, and the Location of Land Use Change Associated with Reservoir Development
(From Hecock and Rooney, 1976)

1. The Character of the Reservoir and Its Facilities

   -- especially with respect to size, shape, water quality, scenery, recreation facilities.

2. The Regional Context of the Reservoir

   -- especially with respect to population settlement, access, climate number and location of other reservoirs.

3. The Character of the Impoundment and Reservoir Development Areas

   -- especially with respect to population, existing land use patterns.

4. The Character of the Land Surrounding the Reservoir

   -- especially with respect to existing land use, land value, and land ownership, but also soil, elevation, drainage, and details of access to the impoundment.

5. The Local Policy Environment

   -- especially with respect to land use controls, availability of roads, and other utilities (water, electricity, sewage), availability of financing, and availability of services (fire, policy, health and education).

Table 6

Hypothesized Spatial Organization of Types of Land Use Impacts, Major Factors, and a Time Table
(From Hecock and Rooney, 1976)

Zone	Anticipated Major Types of Land Use Change	Major Factors Responsible for Determining Extent, Mix, and Locational Details	Time Table
Impoundment Zone (The Conservation Pool Area)	1. Elimination - especially cultivated, pasture woodland, wildlife habitat, vacant or waste land, extractive.	Size, shape, purpose of reservoir; pre-project land use patterns; reservoir management practices may affect extent of elimination or relocation of certain uses (e.g., wildlife habitat, grazing activities, etc.)	Prior to or during construction
	2. Relocation - especially highways, railroads, residences, businesses, utilities, structures, cemeteries, churches, schools.		
	3. Development - especially recreation, power, offices, access roads, maintenance facilities, wildlife habitat.	Project purpose and management practices	Mostly prior to but some after completion
Shoreland Zone (Adjacent to the conservation pool and including some flood pool)	4. Development of Land Uses Attracted by Reservoir - especially seasonal residential, and certain types of businesses.	All of the factors suggested in Table 5 are relevant	Change begins during development, accelerates upon completion, and continues thereafter
	5. Development of Land Uses Attracted in part by Reservoir - especially seasonal residential, businesses.		
	6. Development of Land Uses relocated from reservoir - especially highways, railroads, residences businesses, utilities, etc.		
	7. Reduction in Land Use Associated with any of the above - especially cultivated, woodland, pasture.		
	8. Diversion of rural land to less intensive or vacant for speculative purposes - especially cultivated or pasture to vacant or woodland.		
	9. Development of land uses to service above developments - especially commercial but also some service and utilities.		
	10. Reduction in land uses to services above -- especially to those service land uses which have declined.		

(Continued)

(Table 6, Concluded)

Zone	Anticipated Major Types of Land Use Change	Major Factors Responsible for Determining Extent, Mix, and Locational Details	Time Table
Marginal Impact Zone (area not in the Shoreland Zone but within 3 km (1.8 mi)* of the conservation pool)	11. Development of land uses attraced in part by the reservoir - especially permanent residences, businesses.	All of the factors suggested in Table 5 are relevant	Change tends to begin around completion and grow steadily there-after
	12. Development of land uses relocated from impoundment zone - especially highways, utilities, railroads, residences, businesses.		
	13. Reduction in land use associated with any of the above - especially cultivated, woodland, pasture.		
	14. Diversion of rural land to less intensive or vacant for speculative purposes - especially cultivated or pasture to vacant or woodland.		
	15. Development of land uses to service types 11 and 12.**		
	16. Reduction in land uses to service type 14.		
Zone of No Impact (area over 3 km (1.8 mi)* from the conservation pool)	Land Use Changes not Related to Reservoir Development.	Regional Land Use Trends and Other Local Factors - reservoir not a factor	Before, During, and After Reservoir development

* Selection of the 3-km distance was arbitrary. It corresponded to the approximate distance from which the lake could be seen and it was therefore felt that this area would be reservoir-influenced.

** Service types were not explicitly identified in the report.

land use changes in these areas have an indirect impact over a much wider area by way of effects on environment, government, and economics and social conditions. James (1972) provides a good overview of these indirect effects, both adverse and beneficial. His emphasis is on the economic but he also includes the social, governmental, and environmental and differentiates between local and regional and the regional and national (Table 7).

Impacts on the Natural Environment

Many of the environmental changes brought about by project implementation are clearly recognized and have been listed by various authors; e.g. Keyes (1976) considers possible impacts to vegetation and wildlife:

Vegetation

-- removal of some
-- subjection of the remainder to new influences
-- decrease of those species that depend on wildlife for propagation
-- introduction of nuisance species
-- increased subjection to pollutants
-- subjection to cumulative effects of urbanization
-- subjection to management practices (e.g. periodic mowing, pruning)

Wildlife

-- removal of habitat
-- subjection of habitat and wildlife to pollutants
-- interference with wildlife movement
-- elimination of natural predators
-- introduction of new competitors (e.g. urban-adapted species)
-- infringment on feeding and nesting activities
-- subjection to increased noise and disturbance
-- preponderant increase in some habitats and therefore increased population of certain species

It has long been recognized that habitat is the key to wildlife abundance and distribution. It is also evident that land use is an important determinant of habitat. As stated by Leopold in 1933, "Wildlife is a product of the land and as patterns of land use change, so do wildlife populations." Although these relationships are recognized, they are not well understood. The U.S. Army Engineer Institute for Water Resources (1980) has documented the poor state of the art on relationships among wildlife, habitat, and land use. Major obstacles to improved understanding are the uncertainty as to what the significant variables are and the difficulty/inability to quantify many of the variables. Further, it has been shown that an area can undergo considerable change in land use but that this change may not be a factor in the change exhibited in a wildlife species population density: other aspects of the habitat such as weather, disease, and predation may have an overriding effect (Swanson and Yocom, 1958; Peterka, 1975; Vance 1976; Taylor, Wolfe, and Baxter, 1978). Finally, while many environmental changes can be easily

Table 7

Overview of Potential Indirect Impacts Associated with Reservoir Development
(After James, 1972)

Effect Category	General Range of Impact: Local and Regional — Adverse	Local and Regional — Beneficial	Regional and National — Adverse	Regional and National — Beneficial
Economic	Decrease in property tax revenues Loss of agricultural land Land and housing speculation Depression in local business Decreased incomes	Increase in property tax revenues Increase in acreage or intensity of agricultural land	Loss of agricultural land Losses to GNP Residential development Expansion of local economy Increased incomes	Increased flood control Increased power source Increased housing industry Gains to GNP
Social	New residents dilute community cohesiveness and traditional values Conflicts between permanent and seasonal residents Conflicts with speculators Increased crime	Reduced unemployment Improved labor force Greater community prestige Growth in population	Deterioration of old neighborhoods skills Improved housing	Reduced unemployment Improved labor force skills
Governmental	Increased pressure on existing services Increased problems (crime, pollution, zoning)	Expansion and improvement of services New tax base	Decreased tax revenue	Increased tax revenue
Environmental	Reduced habitat Increased disturbance Increased pollution	———	Dispersal of urban sprawl Reduced habitat	Urban impacts less concentrated Possible elimination of species

observed, others cannot: e.g., cumulative impacts may go unrecognized for years before some critical threshold is reached; also the sequences of induced environmental changes have not been adequately observed, are therefore poorly understood, and so are often unforeseen.

There are many references which address actual and anticipated environmental change consequent to water resources development. These are exemplified by environmental impact statements and the critical reviews prepared by resource agencies and environmental interest groups. However, unlike socio-economic change, aspects of which have been quantitatively studied and documented, environmental change has not been systematically monitored. This is largely because of the difficulties in foreseeing the details of and in establishing a long-term commitment to collecting the appropriate data over several years. The literature is just beginning to discuss schemes for monitoring (Horak and Olson, 1980) while only recently have regulations (Council on Environmental Quality, 1978; U.S. Department of the Interior and U.S. Department of Commerce,1979) been issued.

The literature survey determined that few studies have approached the issue of project effects for the purpose of determining what the actual impact of a project has been on wildlife and what factors have interacted in what way to produce a change in wildlife. Although the literature survey did not find a study which provided a fairly comprehensive and accountable investigation of impacts on wildlife, it did find studies that provide an estimation of some aspects of impact on some species. Examples of these studies are given in Table 8. Among the relatively few studies that have focused on pre- and post-project fish and wildlife in conjunction with water resources development is one being accomplished by the Sport Fishing Institute under contract to the Corps of Engineers. Although this study includes consideration of pre and post-project fish and wildlife conditions at twenty Corps reservoirs, the emphasis is on an evaluation of how well the pre-project projections were realized. The objective was not to determine the project impact factors on wildlife or habitat, nor could that objective be attained with the type of data that has been collected.

Because of the limited focus and divergent approaches of the existing literature, it is difficult to draw conclusions as to how projects affect or may be expected to affect wildlife. Thompson (1977) tries to provide a basis for a better understanding for what constitutes an impact to wildlife and what the major types of impact are.

Thompson supports the idea that impacts to wildlife can be categorized but cannot be judged adverse or beneficial except in the context of carrying capacity (Figure 3). Since it is probably impossible to determine the actual carrying capacity of given area for a given species, he suggests that in most cases an estimate of the existing carrying capacity can be used as a rough approximation. In this context, an adverse impact would be one that either reduces or increases the population relative to the existing carrying capacity or that reduces the existing carrying capacity. Similarly, a beneficial impact would restore depleted or oversized populations to carrying capacity or would increase existing carrying capacity. This concept is not without problems since the key is that impact is measured relative to what is

Table 8

Overview of Key Concerns in Some Representative Studies on Wildlife Impacts Associated with Water Resources Development

Reference	Type of Project	Factors Considered	Species or Species Group
Lewke and Buss (1977)	Impoundment (Snake River Canyon)	Inundation of riparian and floodplain habitat Relative abundance indices Species diversity	Vertebrate animal
Peterka (1975)	Irrigation (North Dakota)	Wildlife population indices Land use patterns incidential to farming	Mourning doves, pheasants, nongame birds, mammals
Whitaker, McCuen, and Brush (1979)	Channel Modification (Delmarva Peninsula)	Species Diversity Species Richness Time since Channel Work	Aquatic macroinvertebrates
Possardt and Dodge (1978)	Stream Channelization (Pennsylvania)	Population Density Standing Crop	Trout, benthos

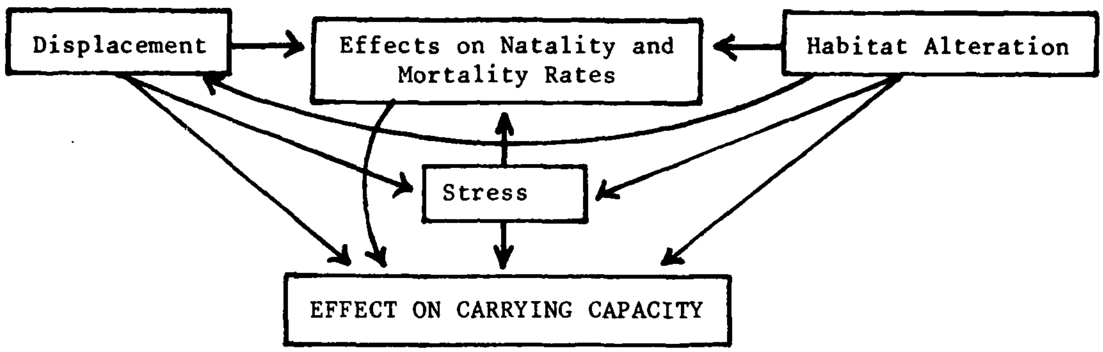


Figure 3. Major types of impacts to wildlife and their effect on carrying capacity. (From Thompson, 1977)

determined as existing capacity. However, the utility of this concept is clear; for example, in cases where habitat has obviously been altered but where the effects of that alteration on wildlife are subtle, then consideration of possible change in carrying capacity may be more meaningful than just measures of change in habitat, habitat quality, or population. As Thompson illustrates, the amount of wilderness habitat left when a road is constructed across a wilderness area is less than the sum of the habitat on either side of the road.

Further, for considering impacts on wildlife via habitat alteration, Thompson differentiates between habitat suitability and actual habitat use:

Habitat suitability is a function of:

vegetation type
patchiness
climate
slope
insolation
availability of food and water
species competition
extent of human disturbance
type of human disturbance
etc.

Actual habitat use is a function of:

habitat suitability
season
weather
tradition
individual animal preference
population density
colonizing ability

By this reasoning then, a project may alter suitable habitat, but that alteration would not be a critical impact unless the habitat was being used and was providing certain species needs that could not be met by other habitat types.

Significance of Literature Findings

Relatively few research efforts have actually studied land use changes associated with water resources development and none has attempted to be comprehensive. Instead, the studies generally focus on one project, one type of project, one type of land use change, or one type of impact. Multiple-regression has been the most often used analytical technique to discern the significant factors involved. Using this method the approach has been to identify potential factors and to then identify which are correlated with variation in actual parameters or values. These studies have probably served

to demonstrate what factors are involved, and to some extent have provided insight into factor interaction; however, they do not enable final conclusions to be made about project-land use relationships.

A major conclusion of the literature review is that the land use that occurs at a given project is essentially an expression of the balance between the influence of the project on the area and the interplay of forces in the area. Thus, the implementation of a project impacts land use in both the immediate and surrounding areas and the nature of that impact is related to the type, size, and purpose of the project as well as to the local and regional environmental, economic, and social vissitudes. Thus, each project is associated with a unique combination of conditions and events that affect the particular patterns of land use that occur over the life of the project.

Although each project is truly site specific and unique, there is a common framework within which the forces affecting land use change occur. This framework, generalized in Figure 4, consists of:

1. The drivers, which are the social, economic, and demographic factors;

2. The limiters, which are the natural capability factors (i.e., the availabilities and suitabilities of lands).

3. The products, which are the land uses.

Another conclusion that may be drawn is that patterns of land use and land use change are not directly dependent on the type of project; studies based on that approach have provided a level of general information, which is probably the extent of information obtainable.

Fischer and Davies (1973) provide a good conclusory summary on project associated changes:

> "The environment is changed through two interrelated development processes: the initial project and the induced private and public projects attracted to the area. This disrupts the physical and social environments. The interdependencies of these environments are complex and cumulative. The intensity, scale, and significance of these environmental changes are severe at the local level. The changes induced are not proportional to the initial project but depend on many interrelated effects of various physical factors and social factors.... The immediate and long-term resultant changes brought about by some intervention such as a water resources development project not only alter some related ecological system, but also affect the perceptions of people living in the locality."

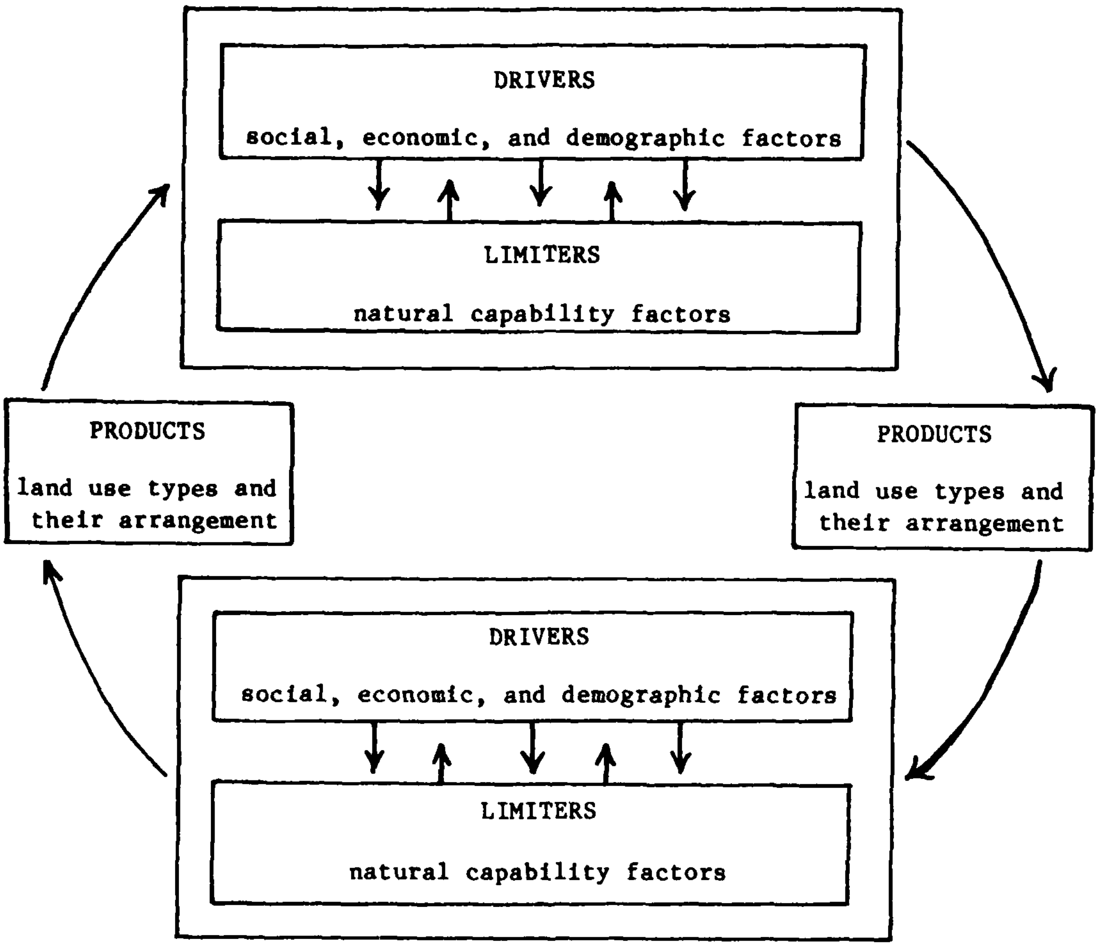


Figure 4. Framework of forces affecting land use change.

CHAPTER IV

OVERVIEW OF LAND USE CONCEPTS FROM A PLANNING PERSPECTIVE

Basis for Variation in Geographic Expression

Simply put, the earth's surface consists of salt water and land. Both types of surface have been extensively used by man but by far the greater portion of activity has been on land. The variation in type and intensity of activity is a geographic expression and centers on man's need to produce crops and materials from the land. Land use then implies an interrelationship between three factors: land, crop, and man (Hills, 1961), in which the distribution of man and crop is affected by the land and in turn affects the land. Thus, the soil, topography, and climate limit the kind and quantity of crop while the crops produced are indicative of the land's productivity. The crops produced and materials needed vary with the social-economic-technological circumstances yet there is probably no area that has not either been in some way influenced by man or that is in some way useful to man. As Hills (1961) points out, the key to the land-crop-man interrelationship is biological productivity and therefore the use of the land should be based on ecological principles.

Environmental characteristics such as soil, topography, and climate are important to the feasibility of types of activities but other factors are involved in explaining the actual use of an area. Delleur et al. (1976) identifies the principal determinants in land use as: population and economic growth, private market forces, land use regulation, public service and facilities, natural features, and public policies and constraints.

Land Use Classifications Reflect Interest in Geographic Expression

Land use has a different meaning in different disciplines. The interpretation given and the types of land emphasized manifest the interests of the discipline. For example, an urban geographer differentiating land uses by the type of development might consider both undeveloped land and abandoned land as unused land and class these in the same category. Similarly, a natural resource manager might differentiate land uses by the dominant vegetation: in this case, developed land regardless of type or intensity of development and non-development, from wilderness to urban center, are a type of land use. In this ecological interpretation, each category of land use represents a different balance between the socio-economic and natural environments which affect and are affected by each other.

Categories of land use differ not only with the purposes of the study but with the study's interpretation of what should be contained within a category. Consider, for example, the variety of definitions of particular types of areas; also consider the difficulties in delineating areas to fit within definitional bounds. Friedmann and Miller (1965) discuss these problems for urban areas and support the use of the term "diffuse urban field."

Although land use classification systems vary they do hold two aspects in common: their philosophical basis and their method of type delineation. Philosophically, the various systems do recognize three basic features: life (whether human, wild, or both), land, and diversity. Hills' (1961) idea of land use as an interaction between land, crop, and man is conceptually within this philosophy but incorporates the view that man has come to dominate or at least affect the majority of the land. Methodologically, the identification of areas by the different classifications is accomplished in the same way (i.e., by recognition of what that study considers to be the significant features of the landscape).

Features that may be considered significant may be selected from the entire array of physical, ecologic, and cultural characteristics and need not be restricted to features visible on maps and photos (e.g., temperature, income). The particular combination of features selected for a given study is chosen for its significance as an indicator of that aspect of geographic variation which expresses the study's concern. The range of variation in those features is used to define the land use categories for that study. Thus, even though the meaning of land use, as evidenced in the particular land use categories considered, varies, it is clear that regardless of study purpose, that that meaning is concerned with variation in geographic expression.

Treatment of Geographic Expression in Planning

Regardless of their discipline or agency, planners are interested in the mechanism of environmental and socio-economic factor interaction that is expressed in land use and its distribution (i.e., patterns of land use). In considering the factors that give rise to an area's land use, planners undertake two basic kinds of studies: land use analysis and land use forecasting. Both of these types include study of locational and use suitability/capability factors. Land use analysis can be applied to past, present, or expected land uses. Land use forecasting incorporates analysis of past and existing uses and of land capabilities to project what the most likely future land use will be.

It is important to note that with respect to future land uses, there are two distinct objectives that planners may have: (a) planning with the intent of controlling future land use, (e.g. as done by a city zoning commission; and (b) planning so as to anticipate future land uses. Corps water resource

planners work within the second objective; the purpose of their studies is to describe the most likely future, describe different futures under the various project alternatives, and compare these futures so as to discern project impacts.

Land Use Analysis

Land use analysis is a process by which diversity of geographic expression is studied. There are three basic steps involved: an inventory of characteristics that appear to contribute to diversity, a classification that delimits the natural groupings of these characteristics, and an interpretation of the various classification categories. The objective of a land use analysis it to determine the functional relationships within or between the natural and cultural systems. However, land use analysis is not a procedure complete within itself, since by providing information in an organized usually graphical way, it enables some characteristics to be better understood and other previously unrecognized characteristics to be discerned.

Land use analysis may be conducted on past, existing, or projected future conditions for which the desired spatial characteristics are known or have been estimated. Whatever time is being studied, the analysts integrate features of the natural and cultural environments in order to separate functioning units on the landscape (i.e., land uses) and to identify the location and suitability factors that explain the position and patterns of the units. In water resources planning, land use analysis is applied to study human influence in terms of development levels on the land in the area of concern. The environmental issues in water resources planning are concerned with assessing the extent to which those development levels intervene on the natural system.

Land use is generally analyzed within the bounds of the system (e.g., cultural or natural), for which the study has concern. For example, if habitat is being assessed, then land uses considered to be non-habitat areas (residential, commercial, etc) are not considered. Similarly, if development is being studied then land uses where development is unlikely (swamps, high relief) are precluded. Since water resources planning confronts both the cultural and the natural, it is actually concerned with the ecological system.

Ecological Land Use Analysis

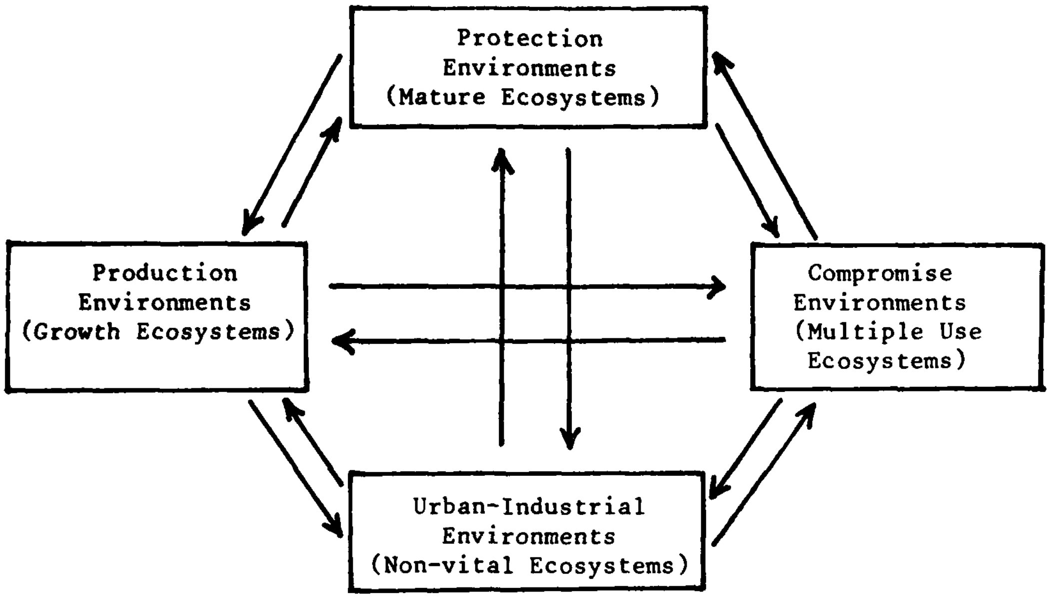
There are a few methods that offer an approach to analysis of the ecological system. These include Hills (1961), E. P. Odum (1969), and Dansereau (1977). In that these methods are for land use analysis, their application requires information on characteristics of the land (i.e., they could be applied to analyze described past, present, or future conditions), but could not be used to reconstruct or forecast a description of those conditions.

Hills (1961) devised his ecological classification of land to provide a basis for decisions in resource management. Because the system is essentially a method of analyzing how lands could best be managed for production, the classes of land considered are confined to farm, forest, fish and wildlife, crops, and recreation. The method consists of two major tasks: first, a classification of natural land qualities, and second, a separation of lands into use classes. The major difficulty with the system is its terminology: it is clear that the ecosystems (also called ecological units and total site types) are delineated on the basis of their combination of physiographic site type and vegetation type, however it is confusing, as to how the hierarchical levels of types are distinguished: landscape units, land types, landtype components, and physiographic types. At any rate, the characteristics or natural land qualities which are considered include: climatic region, relief forms, texture and petrography of geologic materials, soil moisture, depth of rooting zone, local relief. In this system, the particular combinations of these characteristics underlie a consistent pattern of vegetation response.

The Hills system defines various use-capability classes including present uses (uses for which an area is suitable), and uses for which an area is recommended. The factors that are considered to influence man's use of area are: topography, stoniness, structure, drainage patterns, soil erodibility, and the factors of soil productivity. An interesting element of the system is its ability to classify lands according to their capability for production (farm, forest, fish and wildlife, crops, or recreation) and in terms of their relative capabilities on local, broad area, and regional scales.

The method developed by Odum (1969) is far less structured than the Hills system and can accommodate a broader range of land uses since it is not focused on productivity. The Odum method perceives that both the cultural and natural systems may be described in terms of level of development and presents a means of integrating the two within the total landscape. Odum's method is called a compartmental model since it structures the landscape into functioning units which categorize interacting levels of biological productivity and human productivity (Figure 5). Odum's model consists of four compartments which roughly reflect the human use level as well as the stage of natural successional development. Odum also identified 24 measureable ecosystem attributes for use in analyzing successional and developmental stages. These attributes are listed on Table 9. In application of the model, each compartment is associated with particular ranges of values of the characterizing attributes. It is then possible to assess which attributes would most likely be affected by a project and how that impact could be felt throughout the system. Essentially, the model serves to identify the location of and the factors significant in ecological conflict.

Another method of possible use to planners and which also provides an ecological basis for land use analysis is by Dansereau (1977). This land classification is arranged in a hierarchical scheme that incorporates degree of human dominance, processes of exploitation, and types of use and energy levels (Figure 6).



Landscape Compartment	Associated Environmental Character
Production	High level biological productivity
Protection	Ecologically mature, stress tolerable
Compromise	Mix of production and protection environments
Urban/Industrial	Ecologically non-vital

Figure 5. Ecosystem compartmental model developed by Odum. (From Odum, 1969)

Table 9
Ecosystem Attributes Identified by Odum that are Indicative of Successional Development
(After Odum, 1969)

A. Community Energetics

1. Gross production/community respiration (P/R ratio)
2. Gross production/standing crop biomass (P/B ratio)
3. Biomass supported/unit energy flow (B/E ratio)
4. Net community production (yield)
5. Food Chains

B. Community Structure

1. Total organic matter
2. Inorganic nutrients
3. Species diversity - variety component
4. Species diversity - equitability component
5. Biochemical diversity
6. Stratification and spatial heterogeneity (pattern diversity)

C. Life History

1. Niche specialization
2. Size of organism
3. Life cycles

D. Nutrient Cycling

1. Mineral cycles
2. Nutrient exchange rate, between organisms and environment
3. Role of detritus in nutrient regeneration

E. Selection Pressure

1. Growth form
2. Production

F. Overall Homeostasis

1. Internal symbiosis
2. Nutrient conservation
3. Stability (resistance to external perturbations)
4. Entropy
5. Information

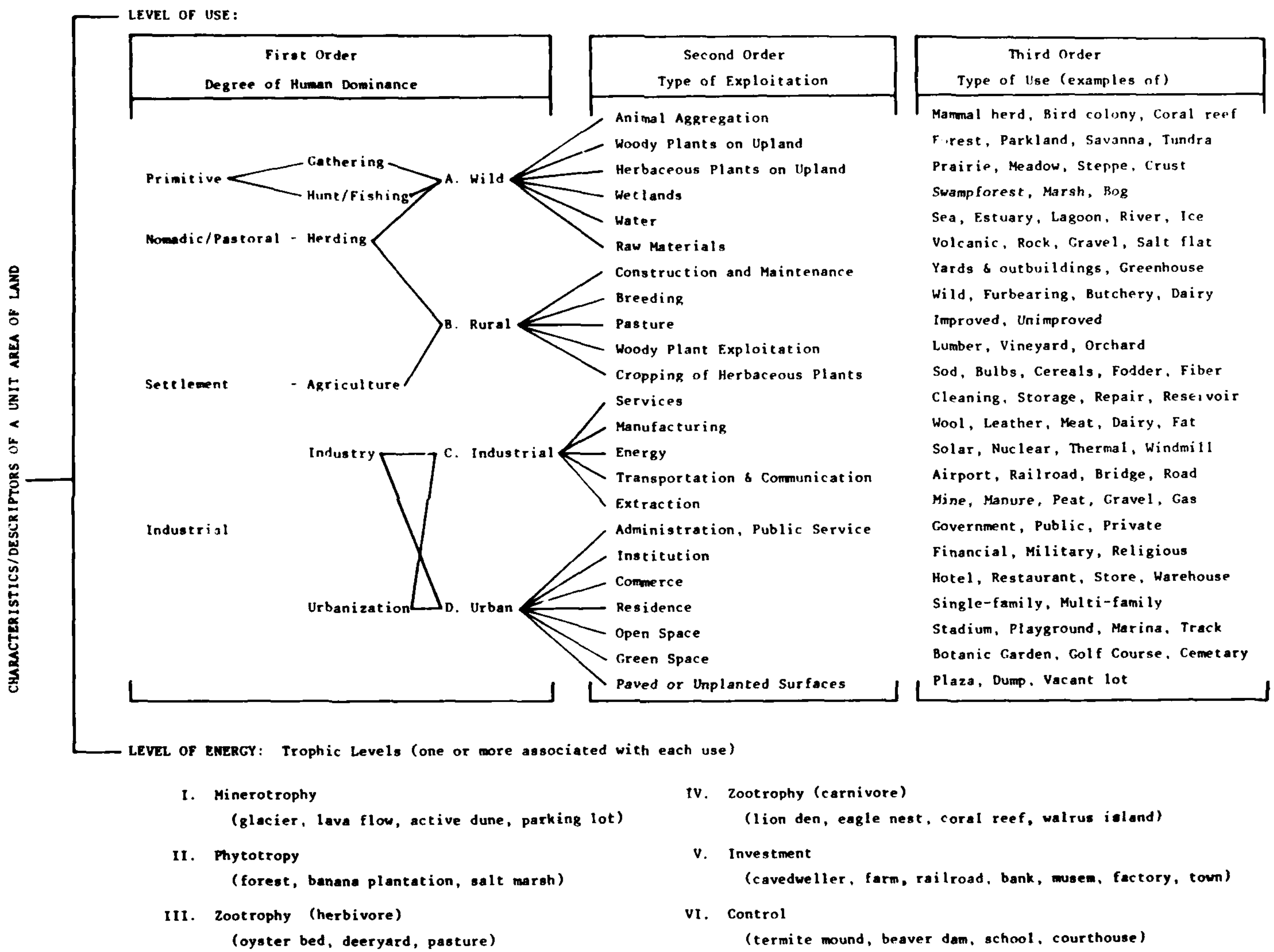


Figure 6. Ecological land occupation classification system developed by Dansereau (1977). (After Dansereau, 1977)

Factors Useful in Land Use Analysis

In addition to the factors selected by Hills, Odum, and Dansereau to apply their methods, there are other factors that have been used to describe land uses (although not within the context of a classification scheme) that have been devised for land use analysis. Examples of these are in Reid (1976) and Wilkinson et al. (1972).

Reid (1976) developed ecological standards for water resources based on determination of the extent to which human development modified existing ecological systems. He rejected the checklist approach (i.e., a listing of factors which could affect the balance and diversity of ecological systems), because of the over simplicity of a factor listing and because for his study the listing would be lengthy. He also rejected an approach based on standard land use catergories because he considered them to be impractical for evaluating human influence on the ecological system. Instead, Reid assumed that the degree of human development and the extent to which a level of development intrudes on the ecological system would be reflected in the response of ecological parameters.

Thus, Reid selected and measured certain socio-economic characteristics as indicators of development and certain ecological parameters as indicators of response. The development level indicators included consideration of inhabitance, land value, water use intensity, and highway transportation. The characteristics and formulas used to measure the development indicators are given in Table 10. The measures for the types of ecological parameters (flora, fauna, and biota are given in Table 11).

Another study of interest for its use of factors to analyze land use is that by Wilkinson et al. (1972). The study employs a development index which summarizes the natural and development characteristics that influence the use of the land. For each type of land use, the study determined the range of value of the factors considered and so determined the development range index for each land use type. The purpose was to provide an analytical tool to supplement zoning, to provide a means for evaluating a given unit of land in terms of what land use types it could support that would be compatible with both the natural and cultural systems on and adjacent to it. Eleven characteristics, including six natural and five developmental were evaluated: at each study unit each characteristic was indexed between a value of one and ten, the summation of the values at a unit became the development index. The characteristics chosen for the study and their individual index scales are given in Table 12.

Synthesis of Main Points on Land Use Analysis

Whether a study undertakes a complete land use analysis process (i.e., the three steps of inventory, classification, and interpretation) or an partial analysis by way of measuring certain indicator factors, certain points are important:

Table 10

Indicators for Level of Human Development Used by Reid
(After Reid, 1976)

Indicator	Measurement
Inhabitance Index (I)	$I = Dr - Dt$ Where Dr = Rural population density Dt = Total population density
Land Value (L)	$L = (UV - \% U\ell) + (Rv = \% R\ell)$ Where UV - Urban value Rv = Rural value $U\ell$ = Urban land $R\ell$ = Rural land
Intensity of Water Use (W)	$W = \frac{\text{Municipal use + industrial use}}{\text{total area}}$
Transportation Facility (T)	$T = \frac{\text{Miles of highway + miles of street}}{\text{total area}}$

Table 11

Ecological Parameters Used by Reid
(After Reid, 1976)

A. Flora

1. Terrestrial natural vegetation (percent change over time)

2. Productivity of aquatic flora

3. Terrestrial flora species diversity

4. Vegetation land use (aesthetic)

B. Biota

1. Pest species

2. Use of carrying capacity, terrestrial grazers

3. Terrestrial food web index

4. Aquatic food web index

C. Fauna

1. Dynamic ratio of fish population (forage/carnivorous ratio)

2. Waterfowl habitat (percent change over time)

3. Terrestrial fauna species diversity

4. Fauna species composition (aesthetic)

Table 12

Natural and Cultural Characteristics, as Selected by Wilkinson et al., that Influence Use of Land
(After Wilkinson et al., 1972)

Characteristic	Index	Measure
Natural Characteristics:		
1. Slope	1	0 - 3%
	5	5 - 8%
	10	8% and above
2. Topographic Complexity	1	Flat or slightly sloped plain surface.
	5	Rolling, defined drainage courses.
	10	Sharply defined land forms and steep walled (15% and above) drainage courses.
3. Drainage	1	Standing water; no defined drainage courses.
	5	Defined drainage ways.
	10	Steep drainage courses, no natural obstructions.
4. Soils	1	Alluvial with little profile.
	5	Well-developed profile.
	10	Exposed rock, thin or no soil cover.
5. Flood Hazard	1	Low areas, frequently flooded.
	5	Land lies within 10 year flood plain.
	10	No chance of flooding.
6. Vegetation	1	None, open soil with thin grass.
	5	Moderate size vegetation with young (15 years) trees and other material from successional phases.
	10	Mature trees (40-50 years).

(Continued)

(Table 12, Concluded)

Characteristic	Index	Measure
Cultural Characteristics:		
1. Land Use (and zoning)	1	Industrial.
	5	Commercial.
	10	Single-family residential or no urban use.
2. Land Modification	1	Entire site graded and filled.
	5	25% of site graded.
	10	No grading or clearing.
3. Adjacent Land Use	1	Industrial.
	5	Commercial.
	10	Single-family residential or no urban use.
4. Unit Size in Square Feet	1	1,000,000 square feet.
	5	250,000 square feet.
	10	100,000 square feet.
5. Access Road Type	1	Expressway.
	5	Major intra-urban thoroughfare.
	10	Local or neighborhood street.

1. That physiographic characteristics are fundamental to land use.

2. That a given area's land use can be described in terms of characteristics of the natural system, characteristics of the cultural system, and the relationships between that particular area and those surrounding it.

3. That the fundamental purposes of land use analysis are to distinguish uses of the land, and to study their locations and factors in location.

4. That land use analysis has utility for planners in evaluating consequences of development, identifying ecologically sensitive areas, and in assessing the use capabilities of land areas.

5. That land use analysis confronts a complexity of interaction between the cultural and natural systems.

Land Use Forecasting

Considered broadly, land use forecasting can address two entirely different but often confused objectives: accurate prediction or reasonable estimation. From a planning perspective, the goal of land use forecasting is to lay out a condition which can be anticipated as being likely to occur. Within the Corps of Engineers planning process, this condition is termed the most probable future; its description enables district planners to develop project plans to meet the needs and problems of that probable condition. Those who equate land use forecasting with accurate prediction, are justifiably confused because they realize that accurate forecasts are impossible and futile. Since they cannot appreciate the concept of a most probable future, they cannot give concientious effort to its development and analysis. The activity then becomes merely an exercise, or in some cases not even attempted. Thus, there are planning studies in which it is assumed that conditions will not change significantly in the future and that therefore the future without condition is the same as the existing condition.

The conceptual framework for accomplishing land use forecasts is basically the same as that which describes the forces affecting land use change (Figure 4). First the driving forces are examined: existing conditions and trends for economic, social, and demographic factors and community preferences are described and analyzed to assess what kind and extent of requirements can be expected over the projection period. Second, these possible requirements are examined with respect to the limiting factors in order to assess how they would likely alter land use and where the alterations would occur. The linkages involved in the forecast process are shown more specifically on Figure 7.

At each target year in the project period, assumptions are made in order to describe reasonable changes in and among the various factors. Expectable changes in land use are then decided. First to consider are lands whose use will not change or whose change is fairly certain. Then logical assumptions

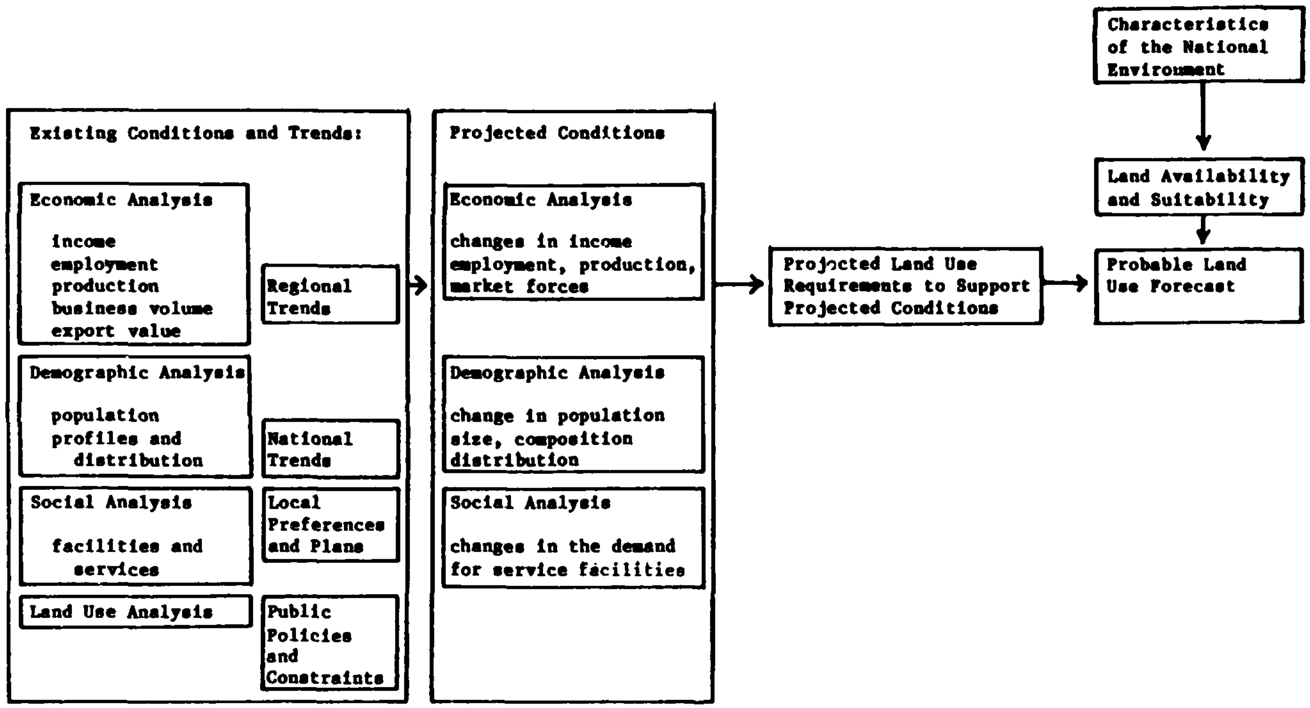


Figure 7. Overview of process for land use forecasting.

are made to assign the projected use of other areas until all lands are accounted for. As target years advance, confidence in the forecast decreases and the network of assumptions increases. In many cases, a point is reached where rationale gives way to conjecture and a target year scenario cannot reasonably be developed. In this situation, planners frequently decide to straight-line conditions from the last target year, or apply conservative rates of change, or state that further projections over the life of the project cannot be reasonably made.

Assignment of expectable uses to lands is facilitated by recognizing certain generalities about changes in land use:

a. That there are stages of institutional development that areas pass through as they evolve from rural to urban (Hahn, 1970).

b. That the extent of change in land uses will be that necessary to support the anticipated change in economic, social, and demographic parameters.

c. That certain combinations of land uses commonly give rise to certain land use patterns (Delleur et al., 1976).

d. That certain uses are clearly incompatible with others.

e. That natural characteristics can act as determinants by providing an opportunity for certain uses and by restraining others.

f. That community policies can act as determinants to uses.

g. That development attracts development; e.g., growth in residential land use frequently takes place through areal expansion (Brandt, 1974).

h. That expansion of uses follows a line of least resistance, e.g., bottomland areas will give way to cropland before upland areas do.

Wuenscher and Starrett (1973) offer a simple procedure for allocating future land uses based on natural characteristics. Although the method was developed for planning the most environmentally compatible use of lands, it could be adapted for use in forecasting the most probable land use. The method incorporates the ecosystem compartment model developed by Odum (Figure 5) to provide a systematic means of analyzing land use and environmental compatibility. Briefly, the characteristics are considered separately in terms of their universal opportunity and restraint for development and protection (Table 13). Land use types are chosen and listed in order of priority of assignment; for example, if protection lands have first priority, those lands would be set aside first, then, of the remaining lands, those of second priority would be set aside and so on. Certain environmental parameters are selected, inventoried at grid intersection data points, and are assigned to a numerical category whose value is dependent on the actual range (Table 14). The category values of all the parameters at each data point are then reviewed and an appropriate land use category

Table 13

Indicators of Opportunities and Restraints for Development and Protection of Lands
(After Wuenscher and Starrett, 1973)

Environmental Characteristic	Indicator for Development: Opportunities	Indicator for Development: Restraints	Indicator for Protection
Physiography	• Good supportive characteristics, elastic bedrock • Stable formations • Flat areas • Good drainage	• Shallow bedrock • Unstable formation, fault zones, mass movement • Steep slopes • Poor drainage • Low bearing capacity • High shrink-swell potential • Poor drainage • High erodibility	• Bluffs, scenic rock outcrops • Significant mineral deposits, gravel deposits, quarries • Floodplains • High production potential
Soils	• Stable support adequate bearing capacity • Good drainage • Resistance to erosion	• Low bearing capacity • High shrink-swell potential • Poor drainage • High erodibility	• High production potential
Water	• Adequate ground water supply or proximity to water system • No flooding problems or seasonally high water table	• Inadequate supply • Runoff from development likely to cause flooding • Too much impervious surface in watershed	• Floodplains and buffer strips along streams • Aquifer recharge areas • Vegetation on steep slopes where rapid runoff may occur
Biotic Communities	• Stable communities • Long-lived species • Aesthetically pleasing plant cover	• Unstable or old-growth communities that would deteriorate as a result of development • Conditions in which lessening density and exposing remaining individuals may cause their death	• Rare or unique species or ecosystems • Highly diverse communities where disturbance would decrease diversity • Flood plain communities • Highly productive forests • Exceptional wildlife habitat

Table 14

Parameters Considered in the Eno River Basin, North Carolina Landscape Compartmentalization Planning Study
(After Wuenscher and Starrett, 1973)

Parameters Selected For Consideration for Planning Land Uses*	Source of Information	Selected Value Ranges (Reflective of area variations)	Numerical Category Value (For classificatory purposes only, not arithemitcally significant)
Distance from Nearest Water Course	USGS Topo maps, 1:24,000	Permanent: within 300′ corridor	9
		beyond 300′ corridor	0
		Intermittant: within 100′ corridor	9
		beyond 100′ corridor	0
Slope		0 - 10%	6
		10 - 25%	7
		> 25%	8
Agricultural Productivity		90 bu. corn/acre	5
		< 90 bu. corn/acre	0
Forest Productivity	SCS field sheets as base maps as well as requests to SCS for value of each parameter for each type	Site Index for loblolly > 90	4
		Site Indes for loblolly < 90	0
Sub-soil Permeability		> .63 inches/hr	3
		< .63 inches/hr	0
Soil Shrink-Swell Potential		Average of less than moderate	2
		Average of moderate or greater	0
Depth of Bedrock		> 5 feet	1
		< 5 feet	0
Position with Respect to Flood Plains	USGS maps of flood-prone areas	In flood-prone area	9
		Out of flood-prone area	0

* Additional parameters could have included Scenic Areas, Unique Recreational Areas, and Unique Wildlife Habitat. However, there were no unique wildlife habitats in the study area, and because the scenic and unique recreational areas occurred only within the river corridors, they would be designated as protection lands.

assigned to that data point. The review is accomplished by a series of logical IF statements arranged in a sequence established so as to sort out land uses in order of priority. Once the appropriate land uses are determined, they can be coded and quickly displayed on computer-generated maps.

In planning for water resources projects, the objective of the land use forecasting task is to describe what is likely to occur so that project impacts can be anticipated and adverse ones minimized through planning. The forecast then, is a statement of the probable future given the existing conditions, trends, and local preferences, and in recognition of the environmental opportunities, restraints, and protection needs. It is important to realize that land use plans are an input, not a product of this task. While land use forecasting is not an easy task, there are procedures available for producing reasonable estimates of expectable socio-economic conditions and their land use expressions. The major difficulty in forecasting is the general lack of capability for evaluating the projected land uses in terms of the natural environment and the future conditions for wildlife.

Capability Analysis

As stated earlier, the two basic techniques that planners employ to describe and study land uses are land use analysis and land use forecasting. Since both of these techniques include some consideration of why a particular area supports a particular use, the sections on land use analysis and forecasting included some mention of capability analysis. This section discusses a few studies using methods with a specific emphasis on capability analysis.

Capability analysis encompasses cultural and natural factors that are indicative of locational preferences and suitability qualifications. In a sense, it could be possible to describe the approximate range of factor values generally associated with a given land use type in a given region. For example, lands suitable for agricultural or residential use in the midwest would exhibit a different range of characteristics than lands under the same uses in New England. Also different factors may prevail: slope may be critical in places with moderate to high relief but be inconsequential where there is little to no relief.

a. Locational preference. In general, locational preference is keyed to what characteristics explain why one site, simply by virtue of its location with respect to other land uses, is more attractive than another for a particular land use.

b. Suitability qualifications. Whereas locational preference is concerned with extrinsic relationships of an area to its surroundings, the characteristics relating to suitability are those which are intrinsically attractive to a given land use.

Both site location and site suitability play a role in the land use type. Their influence may not be completely separable but usually, locational preference is more dependant on cultural factors while suitability

qualifications are more associated with natural factors. Thus, locational preference is generally based on consumer activities such as distance-to factors, transportation access, and costs of living, processing, and distribution. The suitability qualifications are generally given by quality and quantity of resources and natural characteristics such as climate and topography. While two areas may be equally well qualified for a cultural use, one may be preferred over the other because of its juxtaposition to points for goods distribution and consumption.

A well-developed discussion of land use capability is given in McHarg (1971) in which he examines the phenomena of urbanization and describes it in terms of two systems: the pattern of natural processes and the pattern of development. Frequently, urbanization proceeds without regard for natural processes and values but if these two systems can be recognized then their conflict can be reduced and land can be developed to uses compatible with its capability. Essentially, McHarg is pointing out that certain areas are intrinsically suitable for certain uses, that some are better suited than others, and further, that development is best suited to land capability when the relative tolerance of the land to development is considered. McHarg selected eight dominant aspects of natural processes and ranked them in order of natural process value and degree of intolerance to human use:

- -- Surface Water
- -- Marshes
- -- Flood plains
- -- Aquifer Recharge Areas
- -- Aquifers
- -- Steep Slopes
- -- Forests, Woodlands
- -- Flatland

In consideration of natural process values, lands would become more suitable for development as they become more tolerant of human use. Thus of the eight aspects, flatland is the most intrinsically suited to development and surface water the least.

An example of a fairly simple capability analysis technique based on useage standards is given in Sargent and Berke (1979). In this study, underdeveloped areas around a lake were classified according to their suitability for public and private use. For each useage type, a set of standards of what site characteristics would be required for that useage was developed (e.g., a swimming area should have certain beach surface, lake bottom, and access characteristics). Site characteristics included size, slope, soil stability, shoreline type, water quality, site location, scenery, and road access. At each site these characteristics were measured and rated on a numerical scale (1-5). The ratings made it possible to compare sites and to produce a plan indicating the most suitable uses of sites.

Another approach for appraising the suitability of lands for broad use classes in demonstrated by the checklist given in Nowland (1976). The approach recognizes that there is at least a general relationship between land uses and basic properties of the land; e.g., while a particular soil can

preclude some land uses, it does not dictate what particular useage will occur. A key point Nowland makes is that evaluation of land use capability requires information on basic, measureable properties but that this information is used indirectly. Thus, suitability is evaluated from land attributes each of which functions as a description for a particular combination of the basic properties.

As an example, the land uses identified in Nowland (1976) include agriculture, forestry, horticulture, urbanization, building site development, construction materials, sanitary, recreational uses, and wildlife ecology. A listing of the land attributes for three of these land uses conveys the precision and utility of the techniques:

a.	Agriculture --	General physical capability Capability for special crops Indicative suitability relative to other uses
b.	Recreational use --	Parkland suitability Camp areas Picnic areas Playgrounds Pathways Ski areas
c.	Wildlife ecology --	Special preservation and unique areas Outstanding features Erosion hazard

The characteristics of each site are weighted against the land attributes to evaluate its feasible uses. Of course, in order to apply this technique, consideration must be given to what range and combination of properties, both soil and non-soil would describe a particular land attribute (e.g., a ski area would require a certain combination of properties of slope, forest density, and snow thickness, persistence, and type).

In actual application, the types of land uses and land attributes would vary with the individual study. The technique can be used to provide a framework for further site investigation, to determine sensitive areas and, to assist in evaluating appropriate alternative uses.

Another technique which has been frequently used in capability analysis as well as land use analysis is the well-known overlay mapping technique presented by McHarg (1971). Essentially, the method involves the identification and ranking of values of factors indicative of the area's land, water, and air processes. Three grades of values are differentiated for each factor. The occurrence of each factor's grade of value is mapped and when the factor mapes are superimposed the areas where high or low values concentrate become visible. Factors commonly mapped in applications of the technique include: engineering criteria, such as slope, bedrock, geology, soil foundation, soil drainage, and erodibility; vulnerability criteria, such as flood frequencies; and criteria representing evaluation of natural and social processes such as

historic values, water values, forest values, wildlife values, scenic values, recreation values, residential values, institutional values, and land values. The method is very useful for identifying and ranking existing and potential land capabilities; it is particularly useful in that it can be applied to provide information on the interfusion of natural and social processes.

Another approach to capability analysis is by way of carrying capacity. Basically, carrying capacity is a threshold limit, which, if exceeded will result in an alteration of interrelationships among the various elements of a system. In certain contexts, such as grazing pasture and facility useage, carrying capacity is a workable measure; however, in the sense of land use capability analysis, carrying capacity is a concept. Within each of the two system components of land use, i.e., the environmental and the cultural, there are techniques that attempt to incorporate carrying capacity but the treatment in these techniques is so bounded by assumptions that even though it has meaning relative to the interpretation of those procedures, the significance in terms of actual carrying capacity is not known. At present, carrying capacity can be applied in capabilityanalysis but only for a relative comparison among study areas as judged against the scale of carrying capacity values defined for the convenience of the study. The gap between the concept of carrying capacity and the meaning of carrying capacity is frustrating: the utility of carrying capacity for both baseline and capability analysis is recognized; if threshold limits could be determined the concept would become a valuable tool.

A good discussion of the difficulties in dealing with carrying capacity is given in Godschalk and Parker (1975). Clearly, the problems center on definition, measurement, and methodology; further, some resolution of definition of terms and threshold limits is required before problems with measurement and methodology can be approached. Environmental, institutional, and perceptual meanings surrounding the term are often implied rather than defined. Threshold limits appear to have utility, but there are various interpretations of what its limit can refer to. At least three concepts of limit have been used in the literature: the limit to which an activity or population change can occur with:

a. no significant change in the environment; or,
b. with no environmental degradation below certain levels; or,
c. before that activity or population change becomes self-limiting.

Environmentally, carrying capacity could be defined as:

a. The limit at which further human activity will lead to undesirable changes in the environment; or,

b. The limit at which an area of habitat can support a population of a wildlife species.

It seems to be difficult to develop a concept of carrying capacity that integrates human and wildlife activities or even that encompasses a community of wildlife species. Whatever the definition of environmental carrying

capacity is, it is a perception of some aspect of the environment's character, yet as Godschalk and Parker (1975) point out that perception may not be the same as the capacity of the environment. It is possible to evaluate an environment and determine it to be at a satisfactory carrying capacity when actually it is badly degraded; conversely an environment which is perceived to be degraded may be functioning adequately as a natural system.

Perspective on Wildlife via Habitat

The sources of difficulty in forecasting wildlife condition lie in three major areas:

a. The uncertainty inherent to forecasting.

b. The gaps in the understanding of basic ecosystem processes.

c. The lack of interaction between assessments of the natural and the social-economic environments.

Futures projections cannot be made with certainty, yet while this is a difficulty it is not a critical problem because: (a) precison is not the objective; and (b) for planning purposes, techniques are available for projecting reasonable land use estimates. However, forecasting involves more than projecting land uses because an analysis of the projection must be made. This analysis confronts the other areas of difficulty, which do present real problems.

As discussed in Chapter II, gaps in the understanding of ecosystem process are critical. If the relationships between wildlife populations and their environment cannot be clarified under existing conditions when the laboratory of the outdoors is readily available, then how can the future wildlife condition even begin to be described, much less evaluated. Despite the deficiencies, the state of the art has developed sufficiently to establish that the characteristics of wildlife populations are indicative of habitat suitability and productivity of the land. Conversely, it is recognized that habitat quality and quantity are major factors in influencing the distribution, abundance, and health of wildlife. However, there is a limited understanding of how habitat values operate to produce the balance between biotic potential and environmental resistance. Thus, whereas the existing level of understanding permits fairly good assumptions to be made about habitat if the wildlife characteristics are known, the extrapolation of wildlife characteristics from habitat conditions yield a broader range of possibility (Figure 8).

Odum (1977) provides a good discussion of the third major source of difficulty, the separation of economic and ecologic analyses. As Odum points out, close liaison between the environmental and economic assessors would significantly benefit the analysis primarily because the objective of any impact study is actually focused on the interaction between the natural and socio-economic environments. Unfortunately however, ecologists and economists have come to operate nearly to the exclusion of each other as each, in an effort to improve their respective techniques have focused on successively smaller details of components. For example, environmental studies are

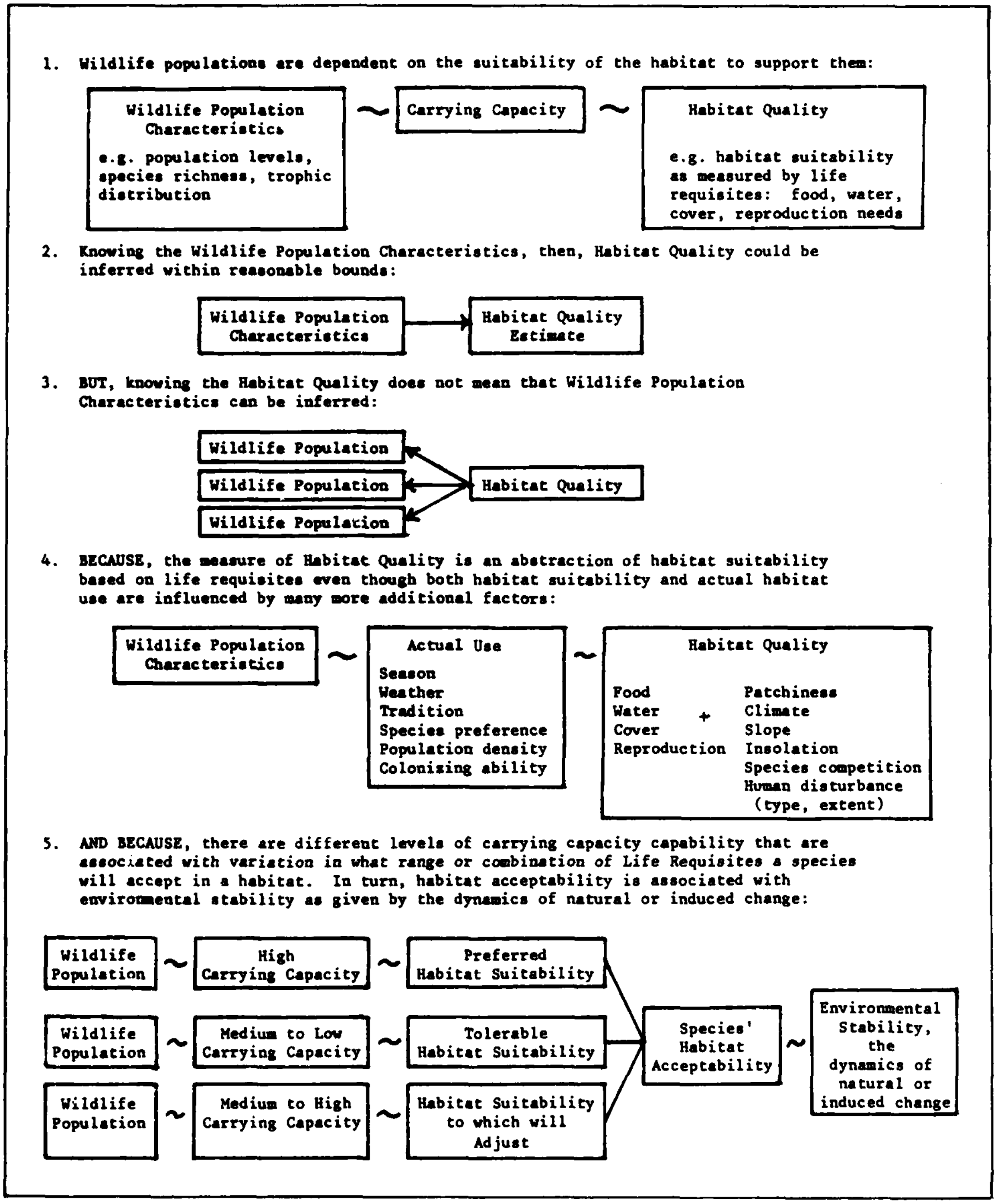


Figure 8. Description of wildlife-habitat relationships based on habitat quality measures is uncertain, particularly in assessing environmental response to land use change.

frequently conducted at the species or factor level when in reality the questions and decisions that need to be addressed occur at the ecosystem level. Although Odum does not include a prescription for integrating economic and ecologic studies, he does argue that an integrative approach would result in findings important to the function of the ecosystem and that those findings could not be discerned by combining separately conducted studies no matter how exhaustive their detail.

In view of the overall capabilities in forecasting and assessing wildlife, the only feasible means for projecting wildlife condition is by way of analyzing the quality of the future habitat. As indicated in Figure 1, the forecast requires several stages of abstraction. The final stage, involving an interpretation of wildlife on the basis of future habitat quality is perhaps the weakest link in the forecast (Figure 8). Once wildlife forecasts are developed, the abstractions on which they are based should not be forgotten. This is particularly important in mitigation planning in which it becomes unreasonable to adhere to projected impacts as if they were hard numbers.

While it is expected that techniques will be developed to enable improved forecasts, it may be that the actual functional relationships for extrapolating wildlife from habitat quality may never be more than grossly defined. Possible improvements may be realized by revising the concept of habitat quality. For example, if habitat quality could be related to factors that are measureable under existing conditions as well as projectable for future conditions, the concept might have a more valid role in impact assessment. However, until techniques are improved, wildlife forecasts will probably continue to be derived from some combination of the following, usually implied assumptions:

a. Developed land has no value for wildlife.

b. Wildlife populations decline in direct proportion to the loss of their habitat (e.g., a 20 percent loss of woodland habitat results in a 20 percent loss of woodland species).

c. Wildlife populations are evenly distributed throughout their ranges.

d. Wildlife population levels are a function of habitat quality.

e. Habitat quality is denoted by the presence/absence of life requisites and is an integration of their measure.

f. The habitat quality of a cover type is the average of the quality of the sites sampled within it.

CHAPTER V

ENVIRONMENTAL PLANNING FOR WATER RESOURCES
DEVELOPMENT - REGULATIONS, GUIDANCE, AND THEIR IMPLEMENTATION

Evolution of Regulations and Guidance

Over the past 45 years or more there have been numerous Federal laws and Corps regulations containing requirements or guidance that affect the substance and approach of Corps water resource development planning studies. A chronological listing of major documents relevant to the environmental aspects of proposed projects is given in Table 15. The table also includes a matrix indicating the main points of each document's content with respect to planning. It should be noted this is not an inclusive listing of regulations issued nor is it a listing of regulations currently in effect. For example, while it is fairly complete for Federal legislation on terrestrial issues, it does not include any Corps regulations prior to 1966; also, the listing contains several documents that have been superceded or rescinded. The purpose of the table is to give an indication of the historical concern for elements that are now considered to be important in planning. It does show, for instance, that the documents have more often been broad and philosophical than specific, and that they have been light on definitions of mitigation and enhancement.

A review of these documents permits some insight into their evolution and how their overall emphasis, or at least the interpretation of them has slightly shifted. As discussed in the following sections, three periods of concern can be distinguished: conservation, impacts, and environmental planning.

Period of Concern for Conservation: 1934 - 1958

From 1934 through the Fish and Wildlife Coordination Act of 1958, the concern seemed to give emphasis to wildlife conservation: to incorporate into project plans, provisions for the conservation, maintenance, and management of wildlife and habitat. The Fish and Wildlife Coordination Act drew attention to a weakness in planning and gave impetus to a new era of concern by stating the following requirement:

> "....there shall be included in any report submitted to Congress supporting a recommendation for authorization of any new project for the control or use of water.... an estimation of the wildlife benefits or losses to be derived from measures recommended specifically for the development and improvement of wildlife resources, the cost of providing wildlife benefits, the part of the cost of joint-use facilities allocated to wildlife, and the part of such costs, if any to be reimbursed by non-Federal interests." (Section 2(f))

Table 15

Development of Elements of Environmental Planning as Indicated By Some Major Documents

Date Issued	Document Identification	Nature of Content: Administrative	Nature of Content: General Philosophy	Nature of Content: Some Degree Specificity	Nature of Content: Ecological Relationships	Elements of Content: Resource Categories	Elements of Content: Condition Significance	Elements of Content: Alternative Futures	Impact Assessment: Identify	Impact Assessment: Estimate	Provision to Offset Impacts: Conservation Measures	Provision to Offset Impacts: Project Modification	Provision to Offset Impacts: Land Acq.	Mitigation	Enhancement
Mar 34	PL 73-121 Conservation of Wildlife, Fish, Game	C		X							X				
Aug 46	PL 79-732 Amend. to Act of 1934	C,D	X						X		X	X	X	A	
Aug 58	PL 85-624 Fish & Wildlife Coordination Act	C,D	X						X	X	X	X	X	U	A
May 62	Senate Doc. 97 Policies, Standards, Procedures	C,D,P	X		A	X		X	X	X	A	A	A	A	U
Jul 65	PL 89-72 Federal Water Project Recreation Act		X	costs		X			X		X	X	X		U
Feb 66	ER 405-2-150 Planning and Project Authorization	D		X									X		
Oct 66	PL 89-669 Protection of Rare & Endangered Species												X		
Mar 67	HR 6731 Amend to Fish & Wildlife Coord Act	C								X					
Jan 70	PL 91-190 NEPA of 1969	I	X		X				X	X	A	A		A	U
Mar 70	EO 11514 Protection and Enhancement of EQ	C,P	X		X										U
Aug 70	ER 1105-2-400 Env. Planning, Rev., Mgmt. Policies	C,1	X	costs	X				X						U
Aug 70	ER 1120-2-401 Preserv., Enhance. F&W Resources	C	X	costs/ coordination					X	X	X				U
Aug 70	ER 1120-2-404 Federal Partic in Rec. Devel.	C		costs					A					U	U
Dec 70	PL 91-611 (sec 122) River & Harbor Flood Control Act			criteria, Corps guidelines					X						
Nov 71	ER 1120-2-400 Recreation Resources Planning	D	X	master planning	X	X			X		X		X	A	U
Oct 72	PL 92-500 Fed. Water Pollution Control Act Amend.		X			X									
Dec 72	ER 1105-2-105 Guidelines, Assess. Econ., Social, Env. Effects										X				
Aug 73	ER 1105-2-129 Preserv. Enhance. F&W Resources	C,D	X	cost sharing					X	X	X		X	U	U
Sep 73	WRC Establishment of Principles & Standards	D	X	X				X	X	X	X	X		A	U
Dec 73	PL 93-205 Endangered Species Act		X		X	X					X				
Nov 75	ER 1105-2-200 series Feasibility Studies, Policies, Procedures	C,I,D,P	X	X	X	X	X	X	X	X	X	X		U	U,T
Oct 76	EP 1165-2-501 Env. Policies, Obj., Guidelines	C,I,P	X		X				X		X	X		U	U
Feb 77	EC 1105 series Env. Considerations	C,I,D,P	X	X	X	X	X	X	X	X	X	X		U,T	
Apr 78	CWB-8, letter F&W Mitigation Policies			X		X	X				X		X	U	
Jul 78	ER 1105-2-200 series Guidelines for Feasibility	C,I,D,P	X	X	X	X	X	X	X	X	X	X		U	U,T
Nov 78	CEQ Regulations for Implementing NEPA	C,I,D,P		EIS Prep., Coordination	X				X	Significance	X	X	A	U,D	U
May 79	CWZ-P, letter F&W Mitigation Policies			X				X	X	X	X	X	X	U	U
May 79	Depts. Int. & Comm. Procedures for Compliance F&W Coord. Act	C,I,D,P		Coordination					X	X	X	X	X	U,T	U,T
Mar 80	OCE Current Corps Mitigation Policy	C,D		X		X	X		X	X	X	X	X	U,T*	U
Apr 80	ER 1165-2-28 Corps Partic. in Improve. for EQ			Criteria for Approval								X			U
Aug 80	ER 200-2-2 Policy and Proc. for Impl. NEPA	C,I,P		Coord., EIS		X		X	X	X				U	
Sep 80	WRC Revision to P&S	C,D,I,P	X	X	X		X	X	X	X	X	X		A	
Sep 80	WRC EQ Evaluation Procedures	I,P		X			X	X	X	X					

Note: Letters used in the body of the Table designate:
A - Alluded to
C - Coordination among agencies specified
D - Documentation or Display requirement
I - Interdisciplinary approach or team required
P - Public involvement specified
T - Term defined
U - Term used but not defined

* CEQ definition quoted, not not clear if that definition was employed.

Period of Concern for Impacts: 1958 -1973

As a result of Section 2 of the Fish and Wildlife Coordination Act, considerable interest was given and continues to be given to estimating proposed project impacts on wildlife resources. The interpretation of what was meant by Section 2f appears to have gone through two phases, recreational/monetary and ecological.

Recreational/monetary point of view. In the initial phase it was recognized that impacts could not be estimated unless there were some process framework for planning. The first fairly comprehensive description of what planning studies should do was given in Senate Document 97, aptly named "Policies, Evaluation, and Review of Plans for the Use and Development of Water and Related Land Resources." This document covered the gamut of planning aspects, from what planning objectives included, to ecological concern, projection of futures, best use of resources, and effects evaluation. However, partly because the document was more often general than specific and partly because evaluation methodologies and criteria were lacking, certain points were adhered to more quickly than others and some of these were subjected to interpretations which were probably some what different from the original intent. For example, consider the following passages from Senate Document 97:

> "Planning....shall...consider...outdoor recreation, as well as sport and commercial fish and wildlife protection and enhancement; preservation of unique areas of natural beauty, historical and scientific interest...." (para. III-B-(1)).
>
> "Full consideration shall be given to the opportunity and need for outdoor recreational and fish and wildlife enhancement...." (para. V-A-5)
>
> "Plans shall indicate in appropriate detail, all facilities needed for full development of the recreation and fish and wildlife potential...." (para. V-A-5)
>
> Fish and wildlife benefits: The value as a result of the project of net increases in recreational, resource preservation, and commercial aspects of fish and wildlife. In the absence of market prices, the value of sport fishing, hunting, and other specific recreational forms of fish and wildlife may be derived or established on the basis of a simulated market giving weight to all pertinent consideration, including charges that recreationists should be willing to pay and to any actual charges being paid by users for comparable opportunities at other installations or on the basis of justifiable alternative costs. Resources preservation includes the intangible value of improvement of habitat and environment for wildlife and the preservation of r e species. Benefits also result from the increase in market value of commercial fish and wildlife less the associated costs (paras. V-E-9 and V-E-10)

Not long after Senate Document 97, the Federal Water Project Recreation Act (1965) was issued. This Act established recreation and fish and wildlife enhancement as full project purposes. Although it reinforced the earlier document's concept of the need to recognize recreation and resource opportunities, the bulk of the Act dealt with cost sharing and costs relationships to project purposes. In hindsight, it is not surprising that fish and wildlife resources came to be handled in the same arena as recreation, that commercial and game species acquired prominence, and that impacts were more often and more clearly expressed in terms of monetary values.

Ecological point of view. With respect to the regulations and for the purposes of this discussion, the first phase of interpretation of how impacts could be evaluated probably ended with the 1967 Amendment to the Fish and Wildlife Coordination Act; however because of the time lag between regulation issuance and regulation implementation, planning studies continued to emphasize a recreational and monetary approach to fish and wildlife for another 7 to 10 years. While the simple statement of the 1967 Amendement recognized that such an approach had become exaggerated, it did not detail any remedy:

> "....no Federal permit or license shall be issued by any department or agency of the United States for the construction of any facility that impounds, diverts, controls, or otherwise modifies such waters until adequate biological and ecological studies on the effects of the proposed construction of the fish and wildlife resources are conducted by the Secretary of the Interior in cooperation with the State wherein the project will be located...." (Section 1)

Then, on the first day of 1970, the National Environmental Policy Act was enacted in order to establish a national policy which was clearly ecological since it declared that it would "...encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation...." (Section 2). In Section 102, NEPA further stipulated that all agencies of the Federal Government shall -

> "(A) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;
>
> (B) Identify and develop methods and procedures.... which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical consideration;" and
>
> (C) Prepare a 5-point EIS.

Soon after NEPA, several documents appeared in support and furtherance of the ecological approach. Prominent among these were:

a. E.O. 11514, Protection and Enhancement of Environmental Quality (1970).

b. The River and Harbor Flood Control Act of 1970, of which Section 122 directed the Corps to issue guidelines to assure that the full complement of economic, social and environmental impacts of proposed actions are fully assessed. In particular, the Act specified consideration of the following items*:

i) air, noise, and water pollution;
ii) destruction or disruption of man-made and natural resources, esthetic values, community cohesion and the availability of public services and facilities;
iii) adverse employment effects and tax and property value losses;
iv) injurious displacement of people, business, and farms; and
v) disruption of desirable community and regional growth.

c. The Corps' 1971 Engineering Manual entitled Environmental Quality in Design of Civil Works Projects:

"Incorporating environmental quality in project design.... involves designing with nature in all of its dimensions -- ecological, visual and human-cultural -- rather than against or onto it. The environmental quality objective imposes a number of broad new requirements on the overall post-authorization planning and design process -- the need to use new types of information and employ new types of talents and skills, and the need to innovate." (p.2, para. 6).

"The underlying ecological concern is for maintenance of the integrity of affected ecosystems, such that necessary actions do not impair their basic structure and function and thus reduce the health, productivity and diversity of man's environment." (p.2, para. 7).

d. The Corps' 1972 regulation entitled Guidelines for Assessment of Economic, Social, and Environmental Effects of Civil Works Projects.

These regulations respond to the requirement of PL 91-611 and constituted a significant attempt to provide for the consideration of non-quantifiable factors in water resources planning.

In August 1973, towards the end of the impact concern period, the Corps issued an Engineering Regulation on the Preservation and Enhancement of Fish

*These items typically appear on summary impact matrices in feasibility reports. However, the linkage between the matrix presentation and the report discussion and findings is often weak or even totally lacking.

and Wildlife Resources.* This ER was most specific on cost sharing, but as evidenced in the following passages, it did not include requirements for evaluating impacts that combined elements of both the recreation/monetary approach and the ecological approach:

> "The advice and recommendation of the fish and wildlife agencies will be requested and adopted to the fullest extent practicable in project evaluation....if the agencies do not furnish estimates of damages and benefits in monetary terms, the reporting officer will accept estimates in terms of recreation days and in quantities of commercial products." (page 6, para. 11a).

> "If a water resource project will result in damage to fish and wildlife, the economic value of such damages will be included as a cost in project formulation and justification, to the extent that such damages are subject to evaluation in monetary terms....Non-monetary damages, including those impacts affecting the eco-system and environmental quality will be described in sufficient detail to support a judgment as to the cost that would be justified to prevent or offset them... Fish and wildlife benefits will be expressed in monetary terms to the extent practicable and appear in the economic evaluation of the project. ...Non-monetary effects, favorable or unfavorable, will be considered in deciding whether contemplated expenditures for enhancement or mitigation are justified." (pages 6 and 7; paras. 11b and 11c.).

Period of Concern for Environmental Planning: 1973 - Present

The Water Resources Council's Principles and Standards (issued September 1973 and effective October 1973) clarified the general philosophy and provided specifics on the various aspects of plan formulation and evaluation. The P&S incorporated the substance of earlier key documents, including the Fish and Wildlife Coordination Act, Senate Document 97, and NEPA, and developed their intent into a broad framework for planning and for comparing, measuring, and judging beneficial and adverse effects of alternative plans. The P&S also provided a succinct compilation of earlier recognized needs for conducting a planning study: agency coordination, decision documentation, display of impacts in terms of relevant physical and ecological criteria, and public involvement.

Subsequent Corps documents established environmental planning guidance and regulations consistent with the P&S and Federal legislative requirements, notably: the 1975 (revised in 1978) Engineering Regulation on policies and procedures for conducting feasibility studies; the 1976 Engineering Pamphlet on environmental policies, objectives, and guidelines; and the 1977 Engineering Circular on policies and procedures for environmental consideration (Table 15).

During this period, the shortcoming of applying fishing, hunting, and recreational use of resources as a means for evaluating impacts on fish and

*Issued as ER 1105-2-129 which superseded ER 1120-2-410 of August 1970, which in turn superseded ER 1165-2-104 of January 1968.

wildlife came to be more widely appreciated. Alternative concepts using physical and biological characteristics as the basis for evaluating the quality of wildlife habitat and assessing impacts proliferated, some becoming fairly sophisticated, and were commonly applied. Although adaptation of an ecological approach is certainly more in keeping with the concepts of the Fish and Wildlife Coordination Act and NEPA, it poses a difficulty that the commercial/recreation use approach did not, i.e. what, among the myriad resources and species in a study area, to choose to evaluate. Both P&S and the Corps regulations for feasibility studies addressed the problem, but formal guidance on resource selection and a framework for the consistent evaluation did not appear until the Water Resources Council issued the Environmental Quality Evaluation Procedures in September 1980.

Also during this period, attempts were made to smooth certain rough spots in the planning process. For example, in 1978 the Council on Environmental Quality issued regulations (effective July 1979) for implementing the procedural provisions of NEPA. The CEQ rules emphasized procedures for interagency coordination and EIS documentation. In particular, they established definitions for the uniform use of terms (including mitigation) a procedure for early resolution of interagency disagreements, and requirements for a concise public record of decisions. In May 1979, the Departments of Commerce and the Interior proposed rules for coupling with the Fish and Wildlife Coordination Act. Two years later these rules had not yet been finalized but if they should become effective, they would have significant requirements, in particular, they would require use of a habitat-based evaluation technique.

Problems Evident Throughout the Regulation History

The implementation of the various regulations highlights certain persistent problem areas. Those which pertain particularly to environmental planning are:

a. decisions as to when a rule applies -- in order to be meaningful to a range of situations, the regulations are full of expressions such as "when applicable", "to the extent possible", and "where practicable." Such wording can probably not be avoided but has two unfortunate consequences: difficulty in knowing when to apply, and a loop hole for non-application.

b. definitions of terms -- terms such as mitigation, conservation, amelioration, enhancement, and compensation have appeared in most of the documents (e.g. Table 15 indicates the use of mitigation and enhancement) but have been defined in relatively few. The great debate of the meaning of mitigation is well-known and may be alleviated by the CEQ definitions in their November 1978 regulations. Similarly, some of the cost-sharing controversy might have been avoided had PL 89-72 (the Federal Water Project Recreation

Act) and ER 1105-2-129 (Preservation and Enhancement of Fish and Wildlife Resources) included a definition of enhancement.*

c. concept of future without -- aside from the difficulties in accomplishing the task there are those who disagree with the concept by arguing that the future with obviates all other futures. At any rate the future without is generally not conscientiously developed; frequently, trends are straight-lined to the final target year or it is assumed that there will be no significant change from existing conditions. Further, although the Corps regulations for feasibility studies state that "a number of reasonable alternative futures should be projected," (Section 290.9(a)(5)), they also state that "The consideration of alternative futures...is essentially at the discretion of the field planner." (item 5 of supplementary information).

d. costs, cost sharing, net benefits, etc.

e. concept of potential and well-being of all the people -- the meaning of these terms as well as the recognition of their achievement are probably as debatable as mitigation and enchancement. Meaning, or interpretation of meaning aside, it is interesting to note that these concepts have not been given much attention in planning. Perhaps if they had there might be a broader appreciation of planning and project objectives.

Requirements of the Corps Planning Process with Respect to Consideration for Fish and Wildlife Resources

Overview of Procedural Requirements

The Corps planning process centers around the 1105-2-200 series of regulations and incorporates the provisions of the Principles and Standards (promulgated by the Water Resources Council). Figure 9 shows a schematic of the three stages and four tasks of the process. The three stages are Reconnaissance, Development of Intermediate Plans, and Development of Detailed Plans. The four planning tasks are Problem Identification, Formulation of Alternatives, Impact Assessment, and Evaluation. The four tasks, each composed of specific activities, are performed in each stage (Table 16) and are iterated as necessary. The different sizes of blocks in Figure 9 indicate the relative emphasis given to the tasks in each stage. Pre-authorization planning generally takes about 2-1/2 to 5 years; Stage 1 is accomplished in approximately 6 to 12 months, Stage 2 in about 12 to 24 months, and Stage 3 on about another 12 to 24 months.

*Even if the definitions were clear and agreed upon there would still be difficulty in recognizing what conditions would satisfy the definitions; e.g. when is mitigation achieved? (see Chapter II, Judging the Response to Change).

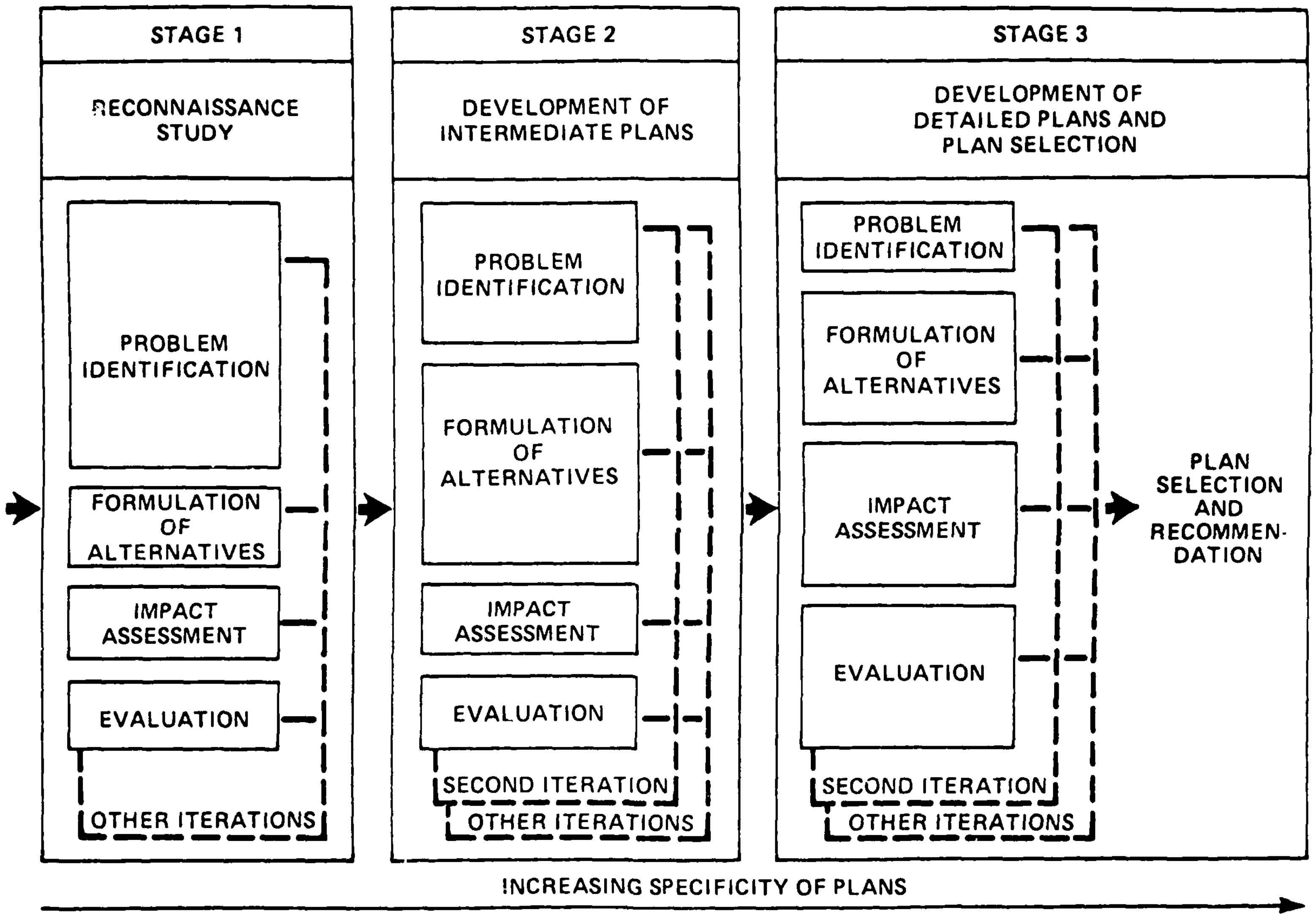


Figure 9. General relationship of plan development stages and functional planning tasks. (From U.S. Army Corps of Engineers, ER 1105-2-200)

Table 16

Framework of Tasks and Activities Within Stages of the Corps Planning Process

Stage	Task	Activity
Reconnaissance (1)	Problem Identification	Identify problems and needs Analyze resource management problems Describe the base conditions (overview) Project future conditions (without project) Establish planning objectives
	Formulation of Alternatives	Identify resource management sources
	Impact Assessment	Identify potential significant impacts (positive and adverse) of proposed management measures
Development of Intermediate Plans (2)	Problem Identification	Specify problems and needs Specify planning objectives Describe the base condition (comprehensive and detailed for key resource parameters) Specify future (without project) condition
	Formulation of Alternatives	Analyze and select resource management measures Formulate an array of distinctively different plans Identify mitigative measures (general to specific)
	Impact Assessment	Identify and quantify major impacts (general to specific) Assess mitigation impacts (general)
	Evaluation	Appraise mitigation fulfillment (general) Appraise planning objective fulfillment (general) Appraise system of accounts contribution (general) Apply specified evaluation criteria (general)
Development of Detailed plans (3)	Impact Assessment	Specify significant impacts Measure impacts Specify mitigation impacts Measure mitigation impacts
	Evaluation	Appraise planning objectives fulfillment Appraise mitigation measure fulfillment Appraise system of accounts contributions Apply specific evaluating criteria Perform tradeoff analysis Designate the NED and the EQ Plan

The following overview of the purpose, focus, and scope of each planning stage with respect to concern for fish and wildlife resources has been compiled from the 200 series as well as the Engineering Circular guidance issued in February 1977 (Environmental Consideration: Proposed Policies and Procedures (FR 42(36)).

Stage 1: Reconnaissance

Purpose. The purpose of the first stage of the planning process is to conduct reconnaissance level investigations to determine whether a survey scope feasibility study is warranted and, if warranted, to develop a detailed scheme for Stage 2 planning. The detailed scheme is best described as a plan of study; this gives some concept of the extent of concerns in Stage 1.

Focus and Scope. Reconnaissance investigations should address the four functional planning tasks primarily on the basis of available information, coordination, and public involvement and should not require detailed analysis. The objectives of Stage 1 are to identify and to consider a broad array of public values and concerns (environmental, economic, social, etc). Resources of particular value or critical concern are highlighted for more detailed study in subsequent planning. From a fish and wildlife point of view, Stage 1 planning attempts to achieve at least a gross appraisal of the study area, i.e., to develop a "broad brush" first approximation compilation of fish and wildlife resources and conditions that constitute the study area's environment. The intent is to determine as early as possible those resources which should be preserved, enhanced, protected, or approached with care. At this stage it is particularly important to identify resources having at least statewide significance; however, features having lesser levels of significance are also considered since local values may indicate whether or not a plan is acceptable.

During Stage 1, data gaps and deficiencies are identified. It may be determined that a monitoring program of selected resource components needs to be initiated to establish what the baseline conditions are. Efforts required to fill these gaps are undertaken in subsequent stages, but the data collection strategy is formulated in Stage 1.

Based on these data and a general understanding of problems and needs in the area, a set of initial planning objectives will be identified including the identification of the range of appropriate resource management measures (channel modification, wetland development, etc). Impact assessment in Stage 1 concentrates primarily on identifying potentially significant impacts of each identified resource management measure. The impact evaluation is concerned with a level of analysis which will provide the basis for determining whether continuation of the study is warranted.

In general, the items to consider and the level of detail envisioned at Stage 1 are broad land use and land cover data including:

a. existing land uses, ecosystems, and major cover types.

b. the predominant species or species association of major cover types.

c. vegetative associations that form a worthwhile contribution to aesthetics.

d. plant and/or animal communities far removed or separated from their natural ranges (outliers)

e. readily apparent problem and hazard areas.

A general guide to the level of environmental detail appropriate to Stage 1 is that which can be discerned from aerial photography (scale of 1:120,000 or larger).

Stage 2: Development of Intermediate Plans

Purpose. In Stage 2 a broad range of alternative plans and management measures are explored. By carrying out sufficient iterations of the four planning tasks, alternatives are screened to decide which plans, if any, warrant more detailed study in Stage 3. Additional data and information are gathered to satisfy any deficiencies in the data base so as to enable future detailed analyses. The level of detail should be sufficient for the public and higher authority to review and understand the rationale used in developing and screening the alternatives.

Focus and Scope. Based on Stage 1 findings and public input, the study emphasis shifts to formulation of alternatives which enables better resolution of what resources ecosystems may and may not be affected. A detailed without project condition is developed for comparison to an extent sufficient to identify major changes from the without condition.

The intent during Stage 2 is to develop a resource information base sufficient to identify all significant effects of the plans under consideration. Since detailed analysis will not be conducted until Stage 3, detailed data need not be selected for any one feature, condition, or resource unless data are readily available. Since some management measures and plans may fall out for various reasons, it is not wise to expend a great deal of time and effort trying to identify all possible impacts of all alternatives; consideration of that level of analysis is reserved for the final array of plans carried into Stage 3.

From a fish and wildlife point of view, Stage 2 level of planning should focus on identifying key species and delineating their life requisite habitats to a level of detail sufficient to perform impact assessment for alternatives being formulated in response to established planning objectives. The emphasis should be on qualitatively (and to some extent quantitatively) describing these resources and their association rather than tabulating species. Specific data collected to fill data gaps identified during Stage 1 and to refine the level of information concerning those resources and areas of particular concern.

The general level of detail envisioned at Stage 2 may be typified for the following examples of activities:

a. analysis of each major cover type identified during Stage 1 to determine areas of specific habitat type and to describe the plant and animal resources and their association.

b. determination of the actual or possible existence of threatened, endangered, or otherwise significant species of plants and animals and their critical habitat.

c. monitoring of any feature of the environment subject to dynamic seasonal changes and for which established base conditions are lacking but are considered necessary to impact assessment.

Stage 3: Development of Detailed Plans

Purpose. Stage 3 is concerned with the detailed assessment and evaluation of the final array of alternative plans. Each alternative plan is developed to a comparable level of detail and to the extent necessary to conduct tradeoff analysis, to designate the NED and EQ plans, and to select the best plan for implementation. Assessment and evaluation in this stage requires data that are specific and well defined.

Focus and Scope. Stages 1 and 2 required a broad overview of the study area's resource data base, data deficiencies, and efforts designed to determine levels of significance. By Stage 3, the inventory and analysis should be sufficiently comprehensive and detailed to perform a final and decisive assessment and evaluation of each alternative plan being considered for recommendation. Accordingly, the focus and scope of Stage 3 is on plan selection, not plan formulation, even though plan reformulation may be required before plan selection and the designation of the NED and EQ plans can be completed.

The key to the level of detail needed is that it be sufficient to enable adequate impact assessment and evaluation. For example, some items to consider would be details on specific vegetation characteristics, and significance of habitat or cover types. Stage 3 attempts to attach quantitative measures where possible to resources determined to be altered or impacted by alternative plans (for example miles of river or areas of forest affected). The actual level of detail required will depend on the significance of anticipated impacts. Determining this will depend largely on professional judgments.

Specific Requirements Imposed by the 200 Series

Essentially, the 200 series simply describes each of the planning activities as to its scope and general philosophy. There is little in these regulations as to how, specifically, the various activities should or could be done, in what detail, and what should be reported. Documentation is infrequently mentioned and sometimes appears to be discouraged. For example, for impacts it is stated that "an extensive listing of all perceived impacts may confuse rather than enlighten" and that for this reason the planner is faced with "the challenge of an adequate comprehensive display". A great deal is left to the discretion of the planner to interpret and to properly and

adequately conduct the activities under the particular circumstances of the study: phrases such as "when appropriate", "compile so as to clearly set forth", and "should be determined" appear throughout. However, according to the 200 series, planning will be thorough and results will be understandable to the public and the decisionmaker; it is up to the creativity of the planner to figure how the philosophy will be implemented.

The following sections provide some remarks on the requirements of the 200 series in relation to the planning activities that are most important to resource evaluation and impact assessment.

Identify problems and needs. The 200 series emphasize public involvement so as to determine which resources present a problem or need that could be addressed by planning. Institutional, public, and technical categories of significance are not mentioned but are implied. "Significance is established by determining if an impact could have a material bearing on decision making."

Describe the base condition. The 200 series provides general guidance on what the description of existing conditions includes. While there is no mention of historical trends or conditions, the description for what the environmental base includes is comprehensive:

> "The description of significant environmental elements in the study area will locate and identify those characteristics deemed to be aesthetically, ecologically, or culturally important. To identify significant environmental elements, factors should be analyzed such as soils, water, air, cities, plants and animals (including people and their culture); forces such as wind, tides, gravity and human activities; conditions such as light, temperature, pollution, and humidity; and processes such as photosynthesis, mineral cycling, and decomposition. This involves inputs from the scientific/professional community as well as the public at large. The description must reflect that environmental elements are important to society in a present as well as future context. As a part of this description, elements should be explicitly identified which are critical in terms of their scarcity, fragility, or lack of resiliency, or which would otherwise be sensitive to change." (Section 292.8(b).

The reporting requirements and possibly the organization of data for use in the study are alluded to as:

> "Careful analysis must be made of information collected about the base condition to establish its adequacy for use throughout the study. If adequate information is not available for the purpose of the study, early efforts must be undertaken to correct the deficiencies. A sound, reasoned determination of needed data must be made early in the process to assure timely acquisition at reasonable cost." (Section 292.8(e).

Project future conditions. The only clear specifics in the 200 series for the projection for futures are that:

a. "The views of various segments of the public concerning their desires for the future of the study area as well as the views of the professional planner should form the basis for projecting future conditions."

b. "Specifications of future conditions should reflect projections currently used by Federal, state, and local planning agencies. OBERS Series E Prime projections will be used as a basis for most studies."

c. "The projections used must be adequate under the criteria of EM 1120-2-118."

d. "The planner must exercise considerable judgment and guard against sampling projections trends."

e. Also, the period of analysis appropriate to each type of study is indicated.

The 200 series is not clear on the projection of with plan futures. Futures appear to be projected in terms of potential sources of impacts rather than conditions. Potential sources are the inputs required to carry out a measure, itself, or the outputs resulting from it. This causative factor approach is sketchily developed in the regulation.

Determine sources of impacts and identify and trace impacts. The level of guidance in the 200 series on effects identification and significance parallels that for forecasting with plan futures. Essentially, each impact cause is to be traced and "the analysis will require tracing an intricate network of causes impacts to the extent practicable." In accomplishing this, "care must be taken to include necessary information on the one hand, but to avoid overloading the process on the other."

Significance is to take into account public values, the scarcity, fragility, or resiliency of the resources, and whether or not "an impact could have a material bearing on decisionmaking."

Rather than requiring a logical thought process and documentation of it, the 200 series states that "impact assessment is essentially objective undertaking." It could be construed that the means for identifying impact is not important.

Measure impacts and specify incidence of impacts. Again, the 200 series requirements are broad and strive to be all-inclusive without giving specific guidance.

The following excerpt from the 200 series relates the requirement on impact magnitude:

"This activity involves describing the magnitude of each change that has been identified. This is a difficult task, since many of the changes can be only in a highly quantitative manner. This is particularly the case

for environmental and social impacts. An attempt to measure all significant impacts, even those of a less tangible nature will be made. Impacts should be described in an appropriate unit of measure or concisely characterized in a written statement. Overdependence or abstract numerical measurement of impacts is likely to result in misleading information." (Section 294.9).

Location is to be described in terms of effects on the region and the nation: the need for precise geographic locations is not mentioned. Duration is to be described as to reversible, irrevisible, short-term, or long-term. The timing of an impact as to whether it is likely to occur during plan implementation, shortly after implementation, or in some other time frame is to be included.

Appraise planning objective fulfillment. In the 200 series, this essentially involves a comparison of significant impacts of a plan and then making a subjective judgment regarding the "degree of satisfaction"; it is not stated what is meant by this term. In reporting the appraisal on the EQ account, a judgment is to be made as to whether EQ is enhanced, is degraded, or destroyed. However, the definition for these or how to recognize such conditions are not clear: in fact it is stated that "while the line between degradation and destruction is rarely clear and precise, this distinction is important."

Display guidance for impact assessment. The 200 series requires that "Significant gross amounts and indications will be presented for the 'base condition,' 'without condition' and all 'with plan' conditions. Emphasis will be placed on quantifying environmental and social impacts in an appropriate manner, e.g. acres of habitat, size of herd or flocks, numbers of trees, miles of shoreline, numbers of people and/or households directly affected (under each of the conditions); and/or brief but adequate descriptions of qualitative factors. Economic impacts will be quantified in dollar terms." (Section 393.9)

The example table to display this presentation, titled "Summary Comparison of Final Alternative Plans," is not detailed and focuses on the four accounts.

Another suggested example display, entitled, "System of Accounts" offers a means to present impacts according to a footnoted classification scheme with the following categories which relate to "the values of the impacts:"

1. Timing

    a. prior to or during implementation
    b. within 15 years following implementation
    c. 15 or more years following implementation

2. Uncertainty

   a. 15% or more
   b. 10-15%
   c. less than 10%

3. Exclusivity

   a. overlapping, fully monetized in NED
   b. overlapping, not fully monetized in NED

4. Actuality

   a. will occur with implementation
   b. will occur only when specific additional actions are carried out during implementation
   c. will not occur because necessary additional actions are lacking

Corps Mitigation Policy

The following summarizes the Corps' mitigation policy on various aspects relating to planning as were effective in Corps documentation issued March 1980. Use of the word key (as in key species) has no definition in biological terms, but is given in this summary because it is given in Corps statements on mitigation policy as well as in the March 1980 documentation.

Use of the USFWS' Habitat Evaluation Procedures (HEP). HEP should not be the basis for measuring the extent of project induced damages. HEP should be used to supplement damage estimates determined using traditional methods (key species, habitat area replacement, etc.).

A traditional analysis is not limited to only the user-day approach, although it has been emphasized and is still appropriate for addressing the NED account. In addition to the user-day and habitat unit analysis, consideration should also be given to in-kind replacement.

Because of significant technical improvements in the current (1980) HEP, it is possible to determine the total habitat unit value for an impacted area and to separate habitat evaluation by species. This enables decisionmakers to determine how many habitat units and/or acres might be needed for each or any combination of species in the analysis.

Justifiable mitigation. Planners should prevent damage to extent practicable by good planning and design. Considerations for determining the extent of justifiable mitigation must include the value of the resources lost. Priority will be given to mitigating and compensating losses to scarce or otherwise significant resources. In justifying mitigation measures, reporting officers are to consider the following.

a. Consideration for value of resource for:

- Recreation; consumptive and non-consumptive
- Commercial use; including direct use, employment, etc.
- Relative scarcity on a regional and national level, including maintaining the integrity and interdependence of significant natural resources.

b. Value of resource must be weighed against the cost of the mitigative measures in terms of:

- Implementation, operation, and maintenance costs
- Economic effects (local tax base, and displacement of residences, businesses and agriculture)

- Social costs
- Negative impacts on other fish and wildlife resources.

Economic feasibility of mitigation features. Corps regulations require inclusion of data on the economic feasibility of mitigation features as incremental elements in a project plan. However, a mitigation plan need not have measured economic outputs equal to or exceeding its cost.

A separate BCR for mitigation should not be computed nor should it be used as the basis for justifying mitigation features.

The description of tangible losses (e.g., commercial/recreational resources plus the intangible losses (e.g., a rookery) must be clearly reported in a way convincing to a reasonable person that the proposed Federal expenditure to replace these losses is justified.

Emphasis on key habitat and/or key species. The purpose of this emphasis is to assure that resources are given appropriate treatment and consideration during impact analysis and mitigation plan development.

This does not mean that the loss of general or common fish and wildlife habitat is insignificant, but that such losses must be placed in the proper perspective when a trade-off decision must be made.

Measures that may be recommended for mitigation at project cost. The measures that may be recommended include:

a. Land acquisition

b. Fish hatcheries and fish stocking activities

c. Storage to maintain minimum streamflow for fisheries

d. Initial development and more intensive wildlife management of existing Federal lands

e. Phased development of lands concurrently with authorized project expansions

f. Initial development and present worth payment for management of existing lands of non-Federal public bodies not necessarily immediately adjacent to the project.

In most cases it is not appropriate for the Corps to provide lump sum payments to state agencies for implementing mitigation measures. The Corps is responsible for seeing that authorized mitigation measures are implemented in a timely manner.

Mitigation through wildlife management. Generally known and accepted wildlife management techniques are suggested for planning the most efficient, least costly, and least land-requiring program to replace significant resource losses. Mitigation plans should be developed regardless of whether or not that plan can fully mitigate or compensate for overall habitat unit losses.

Mitigation through project modification. In some instances it may be more desirable to mitigate for losses by avoiding through project modification. However, benefits foregone and added costs should be justified by the losses to be prevented. It may be necessary to mitigate/compensate for the remaining loss when efforts to reduce resource losses through "avoidance" are not expected to be completely adequate.

In-kind mitigation and mitigation location. Measures for mitigation/compensation should be in-kind whenever possible and provided adjacent to or in the immediate vicinity of the area where the losses occur. In-kind mitigation and/or compensation refers to the same basic habitat types and assemblages and the same basic public use. (Flexibility is given by the word basic, e.g., quail hunting losses could be mitigated by another form of upland game hunting.)

It is generally unacceptable to mitigate or compensate for fish and wildlife (NED) losses at a location some distance from the impacted areas, if the action would preclude or seriously hamper the affected public's access to or use of the mitigation opportunities provided.

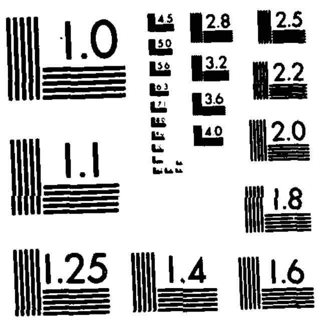
Provisions for a totally different form of wildlife and provisions to benefit a totally different public should generally be considered enhancement and treated accordingly.

Implementation of Regulations and Guidance

The survey of Corps offices, which was undertaken to overview what procedures are used to forecast with and without project conditions and for accounting for those conditions in terms of wildlife, also yielded some perception of how the regulations are addressed in project planning studies. Survey findings regarding procedures for projection of future land use and wildlife conditions are reported in Chapter VI and Appendix A; this section highlights the kinds of issues that have developed in order to translate regulations and requirements into planning study activities.

AD-A123 763 ASSESSMENT OF PROBABLE FUTURE LAND USE AND HABITAT CONDITIONS IN WATER RESOURCES PLANNING(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA M K VINCENT 2/3

UNCLASSIFIED DEC 82 IWR-RR-83-R2 F/G 5/4 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The survey showed that there are three major analytical areas in addressing fish and wildlife concerns in planning: a) estimating future conditions, b) estimating impacts, and c) estimating mitigation. Since each of these areas is essentially an estimation effort, it is inevitable that there are differences in achieving them. The survey determined that these differences relate particularly to the use of assumptions, criteria, techniques, and methods for obtaining, displaying, storing, and analyzing data. However, the differences are difficult to report on in an analytical way because of their myriad variations and because they exist from project to project as well from district to district. Nevertheless, it is clear that in order for environmental planners to be able to establish the assumptions, criteria, and techniques for collecting and using data for accomplishing estimates within the three issue areas, they must first give thought to:

- what kinds and detail of data are needed;
- what data is available and what can be obtained;
- how the data is to be used, including what criteria and assumptions may be applied;
- what particular tools or techniques may be of use in data acquisition, analysis, or documentation (e.g. weighting techniques, scaling techniques, use of multiple methods to improve confidence);
- how the approach, data needs, and techniques may vary with planning stage.

Issues Within the Analytical Areas

While the differences in planning studies are rooted in the collection and use of data and assumptions, decisions concerning these differences cluster around certain issues within each analytical area. This section lists the issues with each of the three analytical areas. Although these issues are universal, the attention given to individual ones varies with the individual study.

I. Issues in Estimating Future Fish and Wildlife Conditions

A. Determining what will be projected

1. Determining what categories of what environmental resources to study (e.g. land uses, vegetative covers, habitats, habitat quality, fish and wildlife populations)

2. Determining target years

3. Determining area over which projections will be made

B. How to estimate fish and wildlife futures

1. Determining what major factors to consider

2. Determining how to use these factors as a basis of estimate

For example, the major factors may include:

a. Those pertinent to the general area including: regional perspective, historical trends in economic and demographic changes, public concerns, recreation needs and demands.

b. Those more pertinent to the study area including: juxtaposition of existing land use types and habitat types, soil capabilities, land capabilities, natural vegetative succession, relationship between habitat quality and quantity (i.e. consideration of habitat condition with regard to fish and wildlife carrying capacity and actual population levels).

3. Overcoming problems specific to urban or to rural areas

C. Expression of future fish and wildlife conditions

1. Format for describing future conditions (e.g. general description of relative change, tabulation of percent change or a real change from baseline, qualitative or quantitative range of probable conditions, map of conditions, etc.)

2. Inclusion of indication of risk and uncertainty in the expression

3. Level of detail necessary (e.g. gross vs. finite)

4. Accounting for variation in value of habitat (e.g. resulting from interspersion of vegetation types; interspersion of land use types; edge effect; effect of linear features; and effect of human disturbance as to the type, frequency, extent, and duration of disturbance)

5. Inclusion of estimate of population level in the expression of fish and wildlife futures

D. Assessment of estimate of future fish and wildlife conditions

1. Level of confidence that might be put on projections

2. Effect of the set of assumptions and criteria on the results (e.g. use of conservative rates of change, straightlining between target years)

II. Issues in Estimating Impacts on Fish and Wildlife

A. Identification of impacts

1. Distinguishing adverse, beneficial, induced, direct vs. indirect, primary vs. secondary, etc.

2. Determining significance of impacts

B. Measurement and expression of impacts (e.g. qualitative, quantitative, gross vs. finite analysis, etc.)

C. Estimation of impacts within project area

1. Impacts directly due to project presence

2. Impacts due to activities such as water level fluctuation, project management, resource management, and recreation (type of recreation activity, location, and intensity)

3. Consideration for natural recovery or recolonization

D. Estimation of impact on off-project lands (e.g. induced development, downstream effects, wildlife range, migration corridors)

E. Estimation of the effect that land uses or land use changes on contiguous areas would have on the fish and wildlife condition of project lands

F. Estimation of the impact on the region, on the Nation

III. Issues in Estimating Fish and Wildlife Mitigation Needs and in Recommending a Mitigation Plan

A. Identification of mitigation need

1. Determining what to mitigate for

2. Determining how much to mitigate

B. Identification of mitigation measures

1. In-kind, out-of-kind

2. Land management, land acquisition, project features

3. Management potential

C. Identification of mitigation plans

1. Appropriate combination of measures

2. Trade-off analysis

3. Basis for the plan (losses to key species, etc.)

4. Appraisal of mitigation fulfillment/adequacy

D. Consideration and recommendation of enhancement measures

Compounding Factors

The survey of Corps offices also acquired knowledge on certain factors that, according to field personnel, compound the difficulties in accomplishing the already difficult and complex estimation efforts of the three analytical areas. Those compounding factors include: interagency coordination, data, confidence in informed opinion and judgment, time and funding constraints, variation in meaning of concepts, public desires and institutional influence, and built-in discouragement (e.g. cost-sharing policies and lack of incentive). Aspects of each of these factors are indicated in the following sections, which summarize statements made by field personnel.

a. Interagency coordination

This primarily concerns differences in Corps and U.S. Fish and Wildlife perceptions as to who should do what and how. Coordination is particularly affected by different philosophical approaches to planning and to the environment. Disagreements as to what is meant by the future without project condition (as opposed to the baseline condition) and mitigation are widespread and hinder coordination.

b. Data

This refers particularly to the lack of data or the lack of confidence in it.

c. Confidence in informed opinion and judgment

This involves the uneasiness in necessarily dealing with a considerable amount of personal judgment that is required to get around data problems, interpretation of trends, interpretation of relationships, and the basic uncertainty in developing future scenarios.

d. Time and funding constraints

Several constraints are involved. Chief among them is dissatisfaction with taking the same approach in each project; however, because time allotted to conducting a study is tight, there is no time to assess the effectiveness or efficiency of an approach or to develop a better one. Changes in policies and regulations, ill-timed receipt of funds, and inability to convert to computer techniques are additional factors that slow planning efficiency.

e. Variation in measuring of concepts

The difference in HEP applications and concepts among USFWS offices can be confusing and is a real problem on a large river basin study when different USFWS offices are involved. However with the user documentation provided in the 1980 HEP, this problem should be alleviated. Other problems relate to lack of definition of wildlife resources, mitigation, and interpretation of habitat units in terms

of wildlife population. Uncertainty about what is considered reasonable for mitigation raises several issues: should it be justified on the basis of the most cost-effective expenditures or the most effective results; is mitigation considered to be achieved only if it is 100 percent; is it better to acquire lands or to develop them; and is mitigation figured only on the basis of losses on project lands.

f. Public desires and institutional influences

The public can thwart recognized opportunities for improving environmental quality by turning them down. This frequently happens if, for example, an EQ-oriented recommendation to restrict development would result in a significant loss to the tax base. In either case the local institutional perception may have little interest in considering least environmentally damaging alternatives; they may only be interested in the least costly, and most effective plan.

g. Built-in discouragement

Cost-sharing policies discourage mitigation: whereas first costs for enhancement may be 100 percent Federal, mitigation costs are shared as for causative purposes. Thus, if the non-Federal agency does not want to participate then it may decide it doesn't want those mitigation features after all. Even if the non-Federal agency does want to participate, other disincentives may exist. For example, why should a plan go after EQ measures when it may be a real struggle to include them and there is no recognition given for having done so. In some studies enhancement measures could be recommended but they are not because they are not acceptable to other agencies until mitigation is achieved and there often is disagreement on what constitutes mitigation. There have been cases in which enhancement features were implemented and which were later involved in repair work to the project; the damages incurred to the features were seen by some as requiring mitigation, that would mean mitigation of the enhancement. Finally, mitigation, at least through land acquisition, is becoming harder to achieve because suitable lands are becoming scarcer.

Some Concepts for Future Possibilities

The literature contains several commentaries on the legislative history of environmental concerns that conclude that NEPA and environmental impact evaluation have truly had a significant effect in preserving and protecting ecosystems even if some of the response actions have appeared to be cosmetic (Liroff, 1980). A few of the commentaries have ventured some concepts as to how existing requirements will be implemented in the near future. Of those with an eye on the future, most regard the CEQ guidelines (issued 29 November 1978, effective 30 July 1979) as having a strong impact on planning in the 1980's. For example:

"The revised CEQ guidelines are affecting the way future projects will be planned. Planning procedures used by project engineers will need to change accordingly, not only to comply with legal requirements, but also to reflect public concerns and funding constraints that increase the viability of innovative and nontraditional solutions to meet the desired objectives." (Boone, 1980).

"The early years of the 1980's will be a period during which Federal agencies will be adapting to the new requirements of the CEQ regulations. During the '80s we should see efforts to follow up on the earliest impact statements, to validate the theories underlying projection of impacts, and to assess whether there was compliance with mitigation and monitoring commitments." (Liroff, 1980).

The CEQ guidelines certainly do impose specific and significant requirements. The guidelines not only feature uniformity of terms and report content but also place a greater emphasis on formulation of alternatives. The term "environmental assessment" is to be used and all environmental assessments are to have a uniform content in addressing the need for proposed action, alternatives to the proposed action, and environmental impacts of the proposed and alternative actions. It is intended that an important function of the CEQ guidelines will be the identification of key environmental considerations early in the planning process, the idea being that this would make it easier to identify mitigation strategies and reduce the occurrence of unexpected environmental problems later in the planning process. It is believed (Boone, 1980) that as a result of the CEQ guidelines, there will be an increase in the effort given to identifying and analyzing alternatives. Ideally, once all agencies have procedures in place to implement the guidelines, all will be using a broader perspective for defining objectives, will be giving more serious attention to nonstructural alternatives, and will pursue increased coordination and consultation with other agencies and the public.

However, while NEPA and the CEQ guidelines have had and will continue to have a significant influence on environmental impact evaluation, an important factor in the continuation of the benefits is the ability to evaluate probable effects rather than environmental actions (Eberhardt, 1976). Another factor is the ability to properly balance the roles of data, technique, judgment, and probability in planning. Perhaps enough planning studies have been accomplished to enable the early '80s to realize that the strategy for environmental assessment must be appropriate to the situation, and that there is no standard method although there have been attempts to contrive one. It may well be that there is already the germ for general recognition that the objective of impact evaluation in planning is to provide environmental information to decisionmakers, rather than detailed data bases, and that a good evaluation requires objectivity, reliability of data bases, and the expression of impacts as likely probabilities instead of as accurate predictions. Perhaps the 1980's will also see the development of improved techniques that (a) will permit some range of probability to be applied to the forecasted parameters and analysis and that (b) will enable a determination of which data are significant to both an environmental analysis and the decision process and what level of accuracy is truly needed.

It is not possible to project what regulations will be forthcoming. However, the Departments of Commerce and the Interior issued proposed rules in May 1979, that, if they ever should become effective would impose requirements as significant as the CEQ guidelines. These proposed rules, which are for compliance with the Fish and Wildlife Coordination Act, include the following:

a. "Findings directed at loss prevention and mitigation measures shall be made using assessment and evaluation techniques based upon wildlife habitat values." (Section 410.24(b)(1)).

b. "To the extent practicable and justifiable, action agencies shall ameliorate project-related losses to wildlife resources, wherever they occur." (Section 410.24(b)(1)) - i.e. the "amelioration" would not be confined to losses within the project area.

c. "...an analysis of the extent of wildlife resource productivity lost to or gained with the proposed project and of the conservation measures required to replace that loss (if that is possible), measured without reference to values attributed to human use ("user day") or other monetary computations." (Section 410.23(c)(3)).

It is likely that the 1980's will see more interest in post-project environmental monitoring and probably even the development of criteria or standards for such monitoring. For one reason, the controversy over mitigation recommendations in planning has spun-off at least one clear realization: that mitigation measures are only conceived in planning and that they require implementation as well as subsequent, perhaps even extensive, adjustment to bring them to satisfactory fulfillment. For another reason, both the CEQ guidelines and the proposed rules for compliance with the Fish and Wildlife Coordination Act give some attention to measures for post-project environmental monitoring. Already, Horak and Olson have discussed the need for standards and criteria to determine mitigation effectiveness and reporting requirements (Horak and Olson, 1980).

A final reasonable projection for the future is that conflict in Federal water resources planning will continue. This is the hypothesis of W.B. Lord (1980), who believes that there are institutional obstacles to effective conflict management within the planning process. According to Lord, "there are structural aspects of existing institutions, both within the planning process itself and in the political structure within which planning is conducted, which mitigate against effective conflict management....The decision-making structure which has evolved over many years is simply inappropriate to the problems it now faces." Lord presents some interesting observations on the reasons for conflict in water resources planning. Although he offers some means for conflict management, he also points out where such measures cannot help but fail. He concludes with the belief that "Only if the structure of the water resources decision-making process changes will the opportunity for effective resources management present itself to water resources planners." Although he does not propose any means for structural change, he does state that "The dilemma is that structural change

is produced by changing public perceptions, which are in turn influenced by the kinds of information which planning can produce. To produce that information will intensify conflict in the short run, while creating the means for its resolution only in the long run.

CHAPTER VI

OVERVIEW OF APPROACHES THAT HAVE BEEN USED FOR ANTICIPATING CHANGES INDUCED BY WATER RESOURCES DEVELOPMENT

Necessity for Planning

Basically, the goals of water resources planning are to anticipate future needs and to prepare for them. Planning produces a framework for the implementation of a project that will permit a desired level of control and use of water and that will concomitantly realize the most acceptable mix of impacts on National Economic Development, Environmental Quality, Regional Development, and Other Social Effects. The philosophy of the approach for water resources planning is set forth in the Water Resources Council's Principles and Standards and in the Corps' planning regulation. The key points of the philosophy are:

a. that a most probable future without project condition is described.
b. that a future project condition is described for each project alternative; and
c. that the impact of an alternative is the difference between the with and without project conditions.

Differences among the alternatives as to their fulfillment of planning objectives and their impacts provide information which is critical to decisionmakers in the selection of the most feasible plan with the most desirable features. Thus, good planning is based on decisions that anticipate probable future problems and needs and that prepares for those conditions by providing a blueprint of the means for accommodating them. In turn, future problems and needs are best anticipated by accomplishing a description and comparison of alternative project plans which represent an array of possibilities for solving the water problems. Well-developed alternative plans include measures for minimizing adverse impacts and taking advantage of opportunities for benefiting both the socio-economic and the natural environments.

Future scenarios are to be based on anticipated changes in economic and social conditions and what land use changes these conditions require. In addition to changes in the socio-economic environment, it is intended that the scenarios include anticipation of changes in the national environment. Existing regulation and policies require: that the consideration given to fish and wildlife be comparable to that given to socio-economic concerns and that the benefits and losses expected to occur under each alternative be estimated. Recent requirements, particularly the revisions to the Principles and Standards (September 1980), emphasize the need for explicit data documentation and record of decisions throughout planning and present a framework for comprehensive evaluation of environmental resources.

Context of Planning

In that planning rests on anticipation of and preparation for future conditions, it has a double-edged aspect of uncertainty and perception. Misunderstandings of planning are rooted in the overemphasis of one of these aspects and if held by the planner or the decisionmaker, can affect the plan which is finally accepted. If uncertainty is overriding, then task accomplishment may seem futile and be poorly done or decisions may be perfunctory. If perception is emphasized then exaggerated accuracy may be attributed to forecasts or impact assessment with the result that some contingencies are foreclosed or that mitigation needs are unreasonably adhered to.

Effective planning acknowledges this double-edged aspect and treats uncertainty and perception in a balance appropriate to the purpose and process of planning. In this context, the approach to forecasting is given by what use can be made of the knowledge available and by realization of the limits of its use.

Forecasting Theory in Planning

Utility of Historical Data

The two basic sources of data and information of use in forecasting are historical data from the study area and patterns of development as evident in historical data from other areas. Use of both data sources requires extrapolation, assumptions, and perception. Utility of historical data is a function of how comprehensive the data is relative to the rate of development that has occurred; however, it can provide some level of information about past trends, variation in trends, correlations among variables, and cyclic components.

In extrapolating historical data to develop forecasts, it is assumed that one or more elements or relationships of the study area's historical data will remain constant. For short-term forecasts, this assumption may be useful, but as the projection period increases, confidence in the reasonableness of the forecast decreases because the likelihood that unprecedented forces and events will occur increases. Perception of what the new forces and events and their effects could be, can be gained from information on historical developments in other areas and can be used to improve the confidence in the forecast. In other types of data extrapolation, future conditions are anticipated as largely being an evolution of past trends and correlations through the extension of those in the study area and also a reflection of those in other areas.

Clearly, historical data is limited in the information it can yield. Gordon and Stover (1976) have identified the general kind of information about the future which is not reflected in historical data:

- Boundary conditions which fix limits to extrapolations
- Biasing conditions which shift the patterns of development of historical data
- Unprecedented events which when they occur are reflected in "deflection" of the extrapolations. Such events, if low probability and high impact, are surprises.

They conclude then, that "Extrapolation can provide an accurate forecast if and only if unprecedented forces and events ... are highly improbable or are of extremely low impact" and that therefore "Combining information derived from historical data with perception and data about unprecedented forces and events is necessary in forecasting."

Building on Historical Data

Forecast development can be greatly improved if historical trend extrapolation is coupled with judgmental perceptions (including imagination) about probable future events, their timing, and their impacts. The U.S. Army Corps of Engineers Institute for Water Resources (1977) provides a comprehensive handbook of available forecasting techniques. Preparation of the handbook involved study of 73 techniques, from which three basic approach categories were discerned:

Time Series and Projections -
which deal principally with methods for trend forecasting essential to identifying and assessing current and potential problems.

Models and Simulations -
which deal principally with methods for gauging interaction among events and hence are essential for measuring the consequences of action.

Qualitative and Holistic Methods -
which deal principally with methods of forecasting the broad context of the future, including societal alternatives and patterns of values on which normative judgments rest.

The handbook selected 12 basic techniques for indepth presentation (Table 17). These 12 were considered to be suitable for a wide range of technological, economic, social, and environmental forecasting and to be the most appropriate to Corps forecasting problems.

It is not possible to compare techniques as to which are better than others or to recommend which are best for land use forecasting. Selection of an appropriate technique is influenced by the many variables of a planning study: e.g., characteristics and size of the study area, level of development, problem being addressed, level of detail needed, data availability, level of certainty about future changes, time, costs, and study resources.

Table 17

Selected, Basic Forecasting Techniques
(After U.S. Army Corps of Engineers Institute for Water Resources, 1977)

Category and Technique	Nature of Results*	Focus of Forecast*
I. Time Series and Projections		
Trend Extrapolation	Qt	Ec, T, S, En
Pattern Identification	Qt, Q, N	Ec, T, S, En, V
Probabilistic Forecasting	Qt	Ec, T, S, En
II. Models and Simulations		
Dynamic Models	Qt, Ql	Ec, S, En
Cross-Impact Analysis	Ql, N	S, En, V, I
KSIM	Qt, Ql, N	S, En, V, I
Input-Output Analysis	Qt	Ec, T
Policy Capture	Ql, N	S, En, V, I
III. Qualitative and Holistic		
Scenarios and Related Methods	Ql, N	Ec, T, S, En, V, I
Expert-Opinion Methods	Ql, N	Ec, T, S, En, V, I
Alternative Futures	Ql, N	Ec, T, S, En, V, I
Values Forecasting	Ql, N	S, En, V, I

* Qt = Quantitative, Ql = Qualitative, N = Normative
Ec = Economic, T = Technological, S = Social
En = Environmental, V = Value, I = Institutional

Forecasting With-Project Land Use and Habitat Changes

Studies Reported in the Literature

Despite the concern for project impacts, there are few studies in the literature that give systematic or detailed attention to the problem of anticipating land use or habitat changes associated with the implementation of water resource development projects. This literature survey identified only eight studies that focused on projecting either land use or habital change; these fell into two categories: (a) ex post simulation models and (b) predictive models.

Ex post Simulation Models

No ex post simulation model of habitat change or habitat quality change was identified in the literature. Four studies presented project-specific models simulating the land use changes which the investigators had measured:

1. Hett (1971), at Watts Bar Dam and Loudon Dam in eastern Tennessee.

2. Burby, Donnelly, and Weiss (1971) at Lake Norman in North Carolina and Lake Sidney Lanier in Georgia.

3. Hecock and Rooney (1976) at Keystone Lake in Oklahoma.

4. Drummond (1977) at Keystone Lake and Pine Creek lake, both in Oklahoma.

The dimensional elements of the studies are given in Tables 18 to 21 while the model mechanisms and evaluation are described below.

A fifth study, by Prebble (1969) of land use changes that occurred over a 34-year period (16 years post-project) in a rural area of Kentucky should be mentioned here because it involved calculating the probability of land use change at individual sites. Although Prebble did not construct a simulation model, the probabilities could have provided the raw data for one. The significance of the Prebble study is that it not only quantified the changes in land use but also related the changes to combinations of factors which it found to be significant. Thus, in the Prebble study, each site was described as possessing some combination of the following significant factors:

1. road access--either has or does not have access by road of a given type*

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*Four road types were identified (I, II, III, IV) and distinguished on the basis of feeder road in a manner similar to the method for identifying stream order through tributary junction. Traveling in the direction away from the lake peninsulas, roads were typed as:

I - no feeder roads except private drives
II - result of the union of two type I roads
III - result of the union of two type II roads
IV - through roads, serving as routes fed by types I, II, or III.

Table 18

Dimensional Elements of the Case Study in the Hett (1971) Simulation Model

Project and Completion Data:

Watts Bar Dam (1942), eastern Tennessee
Fort Loudon Dam (1943), eastern Tennessee

Project Purpose:

Not given

Model Study Area:

1598 sq. mi. of which 62 inundated. Simulation model applied to only 853 sq. mi.

Grid Cell Size:

Approx. 247 acres

Years in Study Period Simulation:

25 years of which 3-4 were in pre-impoundment period

Data Base Dates:

1939, 1953, and variety of aerial photos dated 1960-1966

Actual Magnitude of Development or Change:

All countries shifting from openland to forest, water, urban, and special land uses at rate of 3.24 sq. m./year.
Greatest change was in loss of land to water.
Next greatest change was in increase of forestland.

Land Use or Habitat Types:

Vegetative - Open (primarily agriculture)
Old field (including power-line cuts)
Pine forests or plantations
Cedar-Hardwood
Mixed and Hardwood Forest

Non-Vegetative - Water
Urban
Special (catch-all including steam plans and quarries)

Table 19

Dimensional Elements of the Case Studies in the Burby, Donnelly, Weiss (1971) Simulation Model

Project and Completion Data:

Lake Norman (1961), North Carolina
Lake Sidney Lanier (1956), Georgia

Project Purpose:

For both lakes: power, recreation, stream flow regulation, and water supply.

Model Study Area:

Lake Norman: 311 sq. mi. of which 50.8 inundated
Lake Sidney Lanier: 393 sq. mi. of which 59.4 inundated

Grid Cell Size:

23 acres; each cell divided into 9 parts (2.55 acres each) to which the simulation model allocated residential growth.

Years in Study Period Simulation:

Lake Norman: 9 years, all post impoundment
Lake Sidney Lanier: 14 years, all post impoundment

Data Base Dates:

Variable observation dates (1950 through 1969) for the various factors.

Actual Magnitude of Development or Change:

Lake Norman: increase of 4.2 sq. mi. of residential land.
Lake Sidney Lanier: increase of 5.9 sq. mi. of residential land.

Land Use or Habitat Types:

Residential
Business
Industrial
Public and Institutional
Reservation (lands reserved by industry or reservoir contractor)
Flood
Vacant Land (6 types)

1. Shoreline area: no road access
2. Shoreline area: road access at time of impoundment
3. Shoreline area: road access some time after impoundment
4. Surrounding area: no road access
5. Surrounding area: road access at time of impoundment
6. Surrounding area: road access some time after impoundment

(Shoreline area comprises land within 300 ft of shoreline. Surrounding area comprises land beyond 300 ft and within 2 1/2 miles of shoreline)

Table 20

Dimensional Elements of the Case Study in the Hecock and Rooney (1976) Simulation Model

Project and Completion Data:

Keystone Lake (1964), Oklahoma.

Project Purpose:

Flood control, navigation, power, water supply, recreation

Model Study Area:

148 sq. mi. of which 40.6 inundated (residential land use change model applied to 75 sq. mi).

Grid Cell Size:

123-acre grid cell for measuring general changes
640-acre grid cell for simulating residential development

Years in Study Period Simulation:

12 years of which 6 were post impoundment

Data Base Dates:

1958, 1964, 1970

Actual Magnitude of Development or Change:

Very rural prior to impoundment (96% in pasture, cropland, or woodland). Pronounced urban shift after impoundment but post impoundment acreages not given.

Land Use or Habitat Types:

Residential
Commercial
Manufacturing
Institutional
Highways/Parking
Railroads/Utilities
Extractive
Cultivated Land
Pasture
Woodland
Structures

Table 21

Dimensional Elements of the Case Study in the Drummond (1977) Simulation Model

Project and Completion Data:

Keystone Lake (1964), Oklahoma
Pine Creek Lake (1969), Oklahoma

Project Purpose:

Keystone: flood control, navigation, power, water supply, recreation
Pine Creek: flood control, recreation, water supply, water quality

Model Study Area:

Keystone: 143 sq. mi. of which 40.6 inundated
Pine Creek: 48 sq. mi. of which 5.9 inundated

Grid Cell Size:

Keystone, 62 acres
Pine Creek, 20 acres

Years in Study Period Simulation:

Keystone, 22 years of which 6 were post impoundment
Pine Creek, 19 years of which 5 were post impoundment

Data Base Dates:

Keystone: 1948, 1958, 1964, 1970
Pine Creek: 1955, 1963, 1965, 1970, 1974

Actual Magnitude of Development or Change:

Keystone: More than 95% agricultural prior to inundation. Since completion, substantial residential development near shore; 77% increase in residential over study area.

Pine Creek: Primarily wooded with some farming. Most significant post impoundment development was shift of woodland to pastureland.

Land Use or Habitat Types:

Keystone	Pine Creek
Residential	Residential, Farmsteads
Commercial	
Manufacturing	
Institutional	
Highways/Parking	Highways/Parking
Railroads/Utilities	Railroads/Utilities
Extractive	
Cultivated Land	Cultivated Land/Feedlots
Pasture/Range/Grass	Pasture/Range
Woodland	Forested/Woodland
Impoundment	Lake or Stream Water
	All other (commercial, etc.)

2. peninsular location--either on the tip or the base of a peninsula

3. lake view--either a good, an intermediate, or a poor view of the lake

4. shoreline proximity--either along the shoreline, within one normalized grid cell of the shore, or further inside the peninsula.

5. slope--either steeper than 29 percent, between 11 and 20 percent, or flatter than 11 percent.

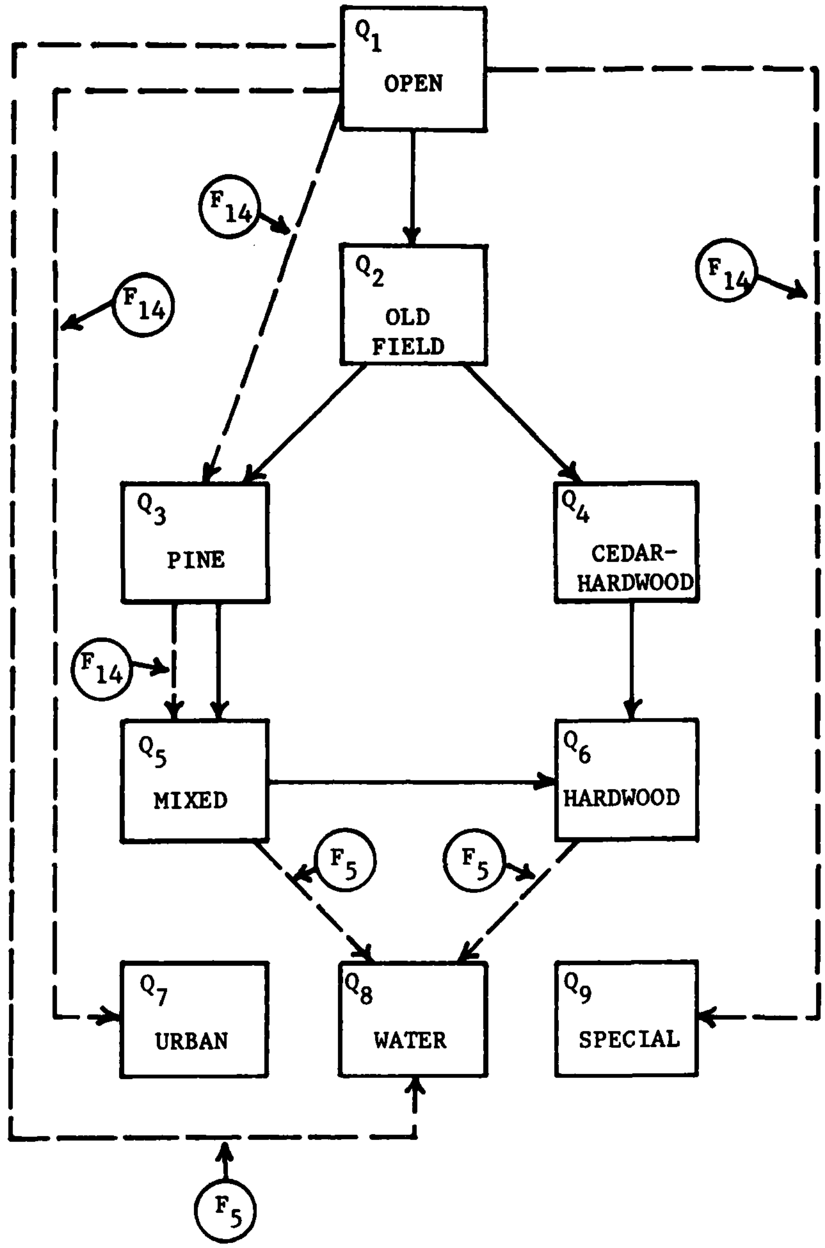
The particular combination of factors at a site was used to estimate the probability of that site's land use changing from agriculture tocommercial, public, or residential use.

Hett (1971). The objective of the study was to describe regional land use changes and to analyze how man influences rates of change. The approach was to: (a) measure changes that occurred in the period between the first and second data base dates, (b) to develop assumptions about the types and rates of change that would occur between the second and third data base dates, (c) to simulate those changes, and (d) to compare the simulated changes with those that actually occurred. Parameters of the study are detailed on Table 18.

The model used in performing the simulation is shown in Figure 10. As illustrated, the model assumed that only certain types of change would occur and that the rate of change would be constant for some types of change and time-varying for others (Table 22). Hett also assumed that (a) urban development would occur along valley systems rather than in the more rugged ridge areas, (b) that increases in the urban or special land use categories would come from open land uses, and (c) that lands flooded by dam waters would be primarily open lands.

In comparing the simulated data with the actual data, Hett found that the model had overestimated mixed forest although the other land use categories achieved adequate estimates of the actual values. Evaluation of the findings led Hett to make two major statements regarding the character of natural and man-induced change and the utility of the simulation technique:

a. Natural succession can be simulated surprisingly well using constant transformation coefficients. When changes from one land use to another involve man's manipulation, the simulation is more difficult and time-varying constants must be used.



F_5 indicates the change occurs during the fifth year, and F_{14} indicates occurrence during the fourteenth year (1953).

-------- indicates man-influenced transformations
________ indicates naturally occurring transformations

Figure 10. Possible land use transformations modeled by Hett (1971). (From Hett, 1971)

Table 22

Summary of Types and Rates of Land Use Change
Assumed by the Hett (1971) Simulation Model

Possible Types of Land Use Change				Rate	Annual Transfer Coefficient
I.	Natural, Successional Types				
1.	Open	---->	Old Field	Constant	0.0130
2.	Old Field	---->	Pine	Constant	0.25
3.	Old Field	---->	Cedar-Hardwood	Constant	0.0002
4.	Pine	---->	Mixed Forest	Constant	0.10
5.	Cedar-Hardwood	---->	Hardwood	Constant	0.25
6.	Mixed	---->	Hardwood	Constant	0.0029
II.	Man-influenced Types				
7.	Open	---->	Pine	Time-varying	0.0000[*] 0.0001[**]
8.	Open	---->	Urban	Time-varying	0.0007[*] 0.0018[**]
9.	Open	---->	Water	Time-varying	0.1650[+]
10.	Open	---->	Special	Time-varying	0.00031[*] 0.0012[**]
11.	Mixed Forest	---->	Water	Time-varying	0.02[+]
12.	Hardwood Forest	---->	Water	Time-varying	0.017[+]
13.	Pine	---->	Mixed Forest	Time-varying	0.1400[*] 0.0130[**]

* coefficient applied in years 1-13 of the simulation (1940-1952)
** coefficient applied in years 14+ of the simulation (1953)
\+ coefficient applied only in year 5 of the simulation (1944)

Note: The two dams were completed in 1942 and 1943.
The transfer coefficients applied to the entire simulation (1940 to 1960-1966, depending on the county) were developed based on changes which occurred between 1939 and 1953.

b. Simulation models can permit a better understanding of what land use changes have occurred and what interactions have produced them. This understanding is useful in perceiving future changes even if those changes cannot be closely modeled.

Burby, Donnelly, and Weiss (1971). These researchers conducted a post-impoundment study of three reservoirs adjacent to metropolitan areas in order to develop a model for simulating residential development patterns in reservoir recreation areas. The model was applied at two of the reservoirs. Prior to model construction, the actual amount of residential development that occurred was determined and an extensive analysis of factors considered to attract it was conducted. This analysis discerned the key attractiveness factors which were built into the model.

The model featured a randomizing procedure for simulating reservoir area residential location decisions: households were assigned to sites (ninths of cells) on the basis of the supply of land available and its attractiveness for recreational and permanent residential use. Following each assignment, to a cell ninth the model was programmed to adjust the supply of land available and the attractiveness weight of the cell receiving growth.

A major point of the study is that residential attractiveness factors vary with the circumstances of the reservoir location, with the distance from the reservoir, and with road access. This is evident in the difference in factors selected for the two study areas and the variation in the regression coefficients for a particular factor within a study area (Table 23). Table 19 details other particulars of the study.

Comparison of simulated development with actual development showed that the model performed satisfactorily for both reservoirs, although in both cases the simulated development was spatially more scattered than the actual. This characteristic of the model to scatter development explained why the simulation was more accurate at Lake Norman than at Lake Sidney Lanier: actual development at Sidney Lanier was more clustered. The difference between the Lakes as to the degree of scattering of actual development appeared to be linked to reservoir ownership and to the amount of development in the surrounding area. While reservoir ownership development policies encouraged clustered development at both lakes, clustering was greater at Lake Sidney Lanier because it had an additional factor contributing to clustering: a greater amount of surrounding area development, which has a natural tendency to cluster.

Deviations between actual and simulated development were also compared cell by cell as to the number of cell ninths accurately allocated. Deviations were not great at either lake and were felt to be due largely to factors of local policy and economy. Factors contributing to overallocation were identified as:

a. company policies and idiosyncracies in the design of Duke Power shoreline subdivision (specific to Lake Norman)
b. oversupply of prime shoreline residential land

Table 23

Regression Coefficients Used in Calculating Attractiveness of Land for Residential Development at Lake Norman and Lake Sidney Lanier
(After Burby, Donnelly, and Weiss, 1971)

Factor	Lake Norman, NC				Lake Sidney Lanier, Ga.			
	Shoreline		Surrounding Area		Shoreline		Surrounding Area	
	No Road Available 1961	Road Available 1961	No Road Available 1961	Road Available 1961	No Road Available 1961	Road Available 1961	No Road Available 1961	Road Available 1961
Ground Cover	3.97	3.54	-.32	-4.81	X	X	-.33	-6.09
Road Distance to Nearest Launch Ramp	-.24	-.15	X	X	NF	NF	NF	NF
Peninsula Location	.65	.68	X	X	.20	.89	X	X
Access to Shoreline	1.85	1.29	X	X	NF	NF	NF	NF
Access to Reservoir Reservation	NF	NF	NF	NF	1.26	2.01	X	X
Aerial Distance from Reservoir Reservation to Shoreline	NF	NF	NF	NF	-3.87	-9.63	X	X
Quality of Available Public Road	X	-9.34	X	25.55	X	-2.98	X	2.46
Road Distance to Nearest CBD	X	X	-.02	-.30				
Road Distance to Atlanta					-1.05	-.76	X	X
Accessibility to Employment	X	X	.32	2.08	X	X	1.03	1.53
Availability of Public or Community Water System	X	X	1.22	9.51	-1.89	-8.35	4.91	1.89
Availability of Public or Community Sewer System	X	X	-.04	.80	5.72	9.11	-1.44	6.48
Change in Availability of Public or Community Water System	NF	NF	NF	NF	4.55	1.15	2.04	5.97

Shoreline Area: area within 300 ft. of shoreline.

Surrounding Area: area beyond 300 ft. of shoreline and within 2 1/2 miles.

Project Completion: Lake Norman completed 1961, Lake Sidney Lanier completed 1956.

X = regression coefficient extremely small.
NF = not determined to be a factor.

c. land otherwise suitable for residential may not have been appealing to consumers because of deficiencies in subdivision design.

Factors contributing to underallocation included:

a. development in cells with low attractiveness actually occurred and may have been because lots were sold at below market rates
b. if the model had not held the attractiveness indices constant over the projection period, it might have been better able to account for the clustering phenomenon, that development attracts development.

Also, the accuracy of the model was to some extent affected by the fact that it did not discriminate the following types of levels in which residential development would be highly unlikely: lands tied up in estate settlement, lands being held for future commmercial and industrial use, or publicly owned vacant lands.

Since the model was developed for and applied in an ex post forecasting situation, certain key items were built into it that would not be known in a true forecasting situation, in particular, the amount of development to allocate and the factors and their relative importance in attracting development. In an actual planning study, an array of development scenarios reflecting various mixes of importance factors and policies would need to be considered.

Burby et. al., (1971) demonstrated that a development model can be a useful tool for planners considering various scenarios or assessing plan alternatives. Their simulation model could be applied to evaluating the effects of alternative land acquisition, road location, and facility development policies, and for forecasting the distribution of residential growth in reservoir areas given an anticipated mix of policy measures.

Hecock and Rooney (1976). The primary emphasis of the research conducted by Hecock and Rooney was to expand understanding of regional impact of reservoir development on land use changes. This was done by hypothesizing a general model of reservoir-associated land use change and by investigating the adequacy of certain variables to predict residential development in an area which received maximum influence from Keystone Reservoir. The study was conducted in conjunction with an effort to evaluate the utility of a land use information system for assessing land use impacts.

The postulated general model, discussed earlier and summarized in Table 6, perceives that the types of land use changes are related to factors of zonal distance from the reservoir and the reservoir construction time table. As indicated on Table 20, the general model was developed using data on land use changes over a 1148-sq. mile study area. For the more detailed focus on residential development, a 75-sq. mile portion of the larger area was selected. This smaller area offered several advantages: a small pre-reservoir population, lack of an urban center, and an extensive amount of shoreline.

The study's prediction of residential development took an attractiveness approach using variables known, from the literature, to stimulate residential

land use: these include availability of vacant land, drinking water, utilities, financing, access, sewage disposal, fire, police, and educational services and the existence of local subdivision regulations. Collectively, the elements attracting development were referred to as the policy environment. The relative attractiveness of an area for development was measured by calculating a Policy Environment Index (PEI) which consisted of both essential and non-essential factors as given on Figure 11. Weights were set up for use in describing each factor, i.e., to indicate absence, presence, or relative attractiveness gradation of factor characteristics (Table 24). Each areal unit* in the study area was then examined, approximate factor weights determined, and the PEI for that unit calculated. The distribution of calculated PEI's was examined and natural breaks in the distribution were used to establish categories reflecting the general level of encouragement for residential development:

1. Harsh
2. Marginal
3. Indirect Access Amenity (policy factors favor development)
4. Direct Access (policy factors very attractive for development).

The four categories were then spatially mapped and an analysis comparing their locations with the distribution of actual residential density was made. As expected, the densities correlated well with the four categories of development attractiveness. However, it should be noted that the prediction of development was given in qualitative terms or surmizes as to relative level of development, not actual quantitative predictions of the number or density of dwelling units. The methods discerned policy environment development factors and compared relative densities with the four PEI categories.

The authors concluded that the PEI model has potential for planners in constructing a realistic index of the overall policy environment. They believe that the basic structure of the model needs no improved modification; that adaptation of the model to other areas would only require modification of factors, weights, and weighting criteria.

Drummond (1977). Drummond studied the land use changes that occurred at two Corps projects and developed a dynamic land use model to simulate post project land uses and to project what land uses would have existed if the projects had not been built. The purposes were to evaluate the feasibility of predicting land use patterns and to appraise what the differential impact of water resources development had been (i.e., the ex post difference between the without project and the with project conditions). The land use model incorporated the Markov process, a statistical procedure that economists frequently use for measuring the change in economic variables through time and in estimating what values these variables may have at future times. Essentially, the technique assumes that changes occur through a chain process; that the likelihood of occurrence is linked to earlier occurrence.

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*The square-mile areal units corresponded to the U.S. Land Survey System development plats.

The Policy Environment Index (PEI) is a measure of the relative attractiveness of the policy environment for development.

The equation for PEI is:

PEI = Essential Factors x Non-essential Factors

The fully expanded equation is:

$$PEI = [L \cdot W \cdot U \cdot (PM + GMH + GMD) \cdot Ac] \cdot [(X + \text{[illegible]} + Lk) + (S + MR + C) + (FP + PP + E)] \div 100$$

PEI = Policy Environment Index

(EF) Essential Factors
- L = Availability of Land
- W = Availability of Drinking Water
- U = Availability of Utilities
- (F) = Finance Package
  - PM = Availability of Private Financing
  - GMH = Availability of Government Financing for Home Buyers
  - GMD = Availability of Government Financing for Special Districts
- Ac = Availability of Access

(NEF) Non-Essential Factors
- (Am) Amenity Package
  - X = Exurban Amenity Constant
  - Lk = Availability of Lake
- (SR) Subdivision Regulation Package
  - S = Sewage Disposal Regulation
  - MR = Metropolitan Subdivision Regulation
  - CR = County Subdivision Regulation
- (SSD) Special Service District Package
  - FP = Availability of Fire Protection
  - PP = Availability of Police Protection
  - E = Availability of Education for Children

Figure 11. The policy environment index (PEI) developed by Hecock and Rooney (1976). (From Hecock and Rooney, 1976)

Table 24

The Weighting Criteria and Composition of the Policy Environment Index Factors
(From Hecock and Rooney, 1976)

Factor	Weights	Weighting Criteria
L	0	Unavailable due to zoning or policy of controlling organization
	1	Available land
W	0	Unavailable due to the policies of the organization or the physical limitations of the system
	1	Available supply is severely restricted due to either policies or physical limitations
	2	Available, section is 2 miles or more from a main supply line
	5	Available, section is 1 mile from a main water supply line
	8	Available, section is located in the same area as a major fresh-water aquifier, hence wells can be used with confidence
	10	Available, section contains or is adjacent to a main water supply line
U	0	Unavailable
	2.5	Available if developers pay for utility line installation and the section is not adjacent to an existing main line
	5	Available if developer pays for utility line installation and the section is adjacent to an existing main utility line
	10	Available with the utility company installing the lines with no charge to the developer
PM	0	Under 20% of potential home buyers cannot afford a conventional bank home loan
	1	Over 20% and under 50% of potential home buyers can afford a conventional bank home loan
	3	Over 50% of potential home buyers can afford a conventional bank home loan
S	0	Lagoon sewage disposal system is favored by regulating agency (50% or more developments are on a lagoon system)
	1	50% or more of the developments are on septic tanks
	2	Availability of a rural or extended metropolitan sewer line is present
MR	0	Definitely regulation present
	1	Jurisdiction control is ambiguous
	2	No regulations present
CR	0	County subdivision regulations present
	1	Jurisdictional control is ambiguous
	2	County subdivision regulations absent
FP	0	Fire protection is not available
	1	Fire protection is available
PP	0	Police patrolling is unavailable
	1	Police patrolling is available
E	0	Schooling is not available
	1	Schooling is available

The transformation through which the chain process operates may be stationary or dynamic.

Drummond applied both stationary and dynamic transformation probabilities to project land uses. Table 21 summarizes the key data elements of the study. It was assumed that land found to be in any given use in two consecutive time periods had continued in that use during the interim period. Development of the transition probabilities for the model required a considerable amount of data.

Comparison of simulated with actual land use acreages showed the stationary probabilities to be more useful than the dynamic; in fact the attempts with the dynamic transition probabilities were deemed to be generally unsuccessful. Drummond believed there were several reasons for this. First, because the dynamic methodology requires more data, it has more problems. Second, the techniques available for estimating the adjustments for dynamic transitions are limited. Third, the dynamic probability procedure averages changes over several periods of time and so characterizes the average of all time periods rather than a particular time period. The net result is that the dynamic probabilities obscure more than they reveal.

The results also indicated that the methodology is sensitive to the particular characteristics of an area. For example, the simulations for Pine Creek Lake unexpectedly overestimated residential and other development uses. This was because the model did not take into account Corps regulations prohibiting private use of land within flood pool areas and since the flood pool at Pine Creek is 4 1/2 times the conservation pool, the omission was magnified.

Although the estimates of differential land use change cannot be verified (i.e., the amount of land use change that would have occurred without the projects), they were generally consistent with a priori expectations and the author concluded that the methodology does have application for evaluating project impacts under ex post conditions.

Predictive Models

The four ex post simulation models just described do provide methodologies for predicting land use change; however, as applied in these studies their approach was simulative rather than predictive since the input data included measures of post-project changes. The literature survey did not determine any studies that actually outlined and applied a model for projecting land use and/or habitat change associated with water resource development. Since this statement may seem surprising, it should be made clear that the survey was searching for studies which met the following criteria:

a. dealt with water resources development,
b. projected a without project future as opposed to superimposing a future project on existing conditions,
c. specified the strategy and assumptions used,

d. produced quantitative or at least qualified qualitative information on the location, extent, and timing of anticipated changes.

Although no such study was found, a few presented a predictive approach which is described here. The references selected for this section are not confined to water resources development:

a. Cowan (1972); surface water impoundment
b. Carlisle and Park (1976); wastewater treatment facility
c. Fabos, Green, and Joyner (1978); responsible regional landscape planning.
d. Miller, Tom, and Nualchawee (1977); urban development.
e. Asherin, Short, and Roelle (1979); coal resource development.
f. Potter and Kessell (1980); environmental response to forest fire.

Cowan (1972). Cowan developed a means for estimating the environmental impact of the Platte Dam, a 125-square mile Corps impoundment proposed for the Platte River between Omaha and Lincoln, Nebraska. The method developed provided a technique for objectively and logically quantifying the anticipated ecological impact of the dam on selected gross habitat categories as well as on agriculture and recreation. The mechanisms of the technique are based on the probabilities of resources and the desires or demands for the resources. The assumptions concerning the probabilities of supply and demand of resources are stated in terms of relative truth. For example, if it is assumed that areas having high primary production potential are more likely to be valuable to living things than those of low potential, then (a) statements can be set up

Statement A = High productivity
Statement B = Demand for habitat
Statement E = Greatest ecological importance

and (b) can be related mathematically in terms of probabilities:

$$P(ABIE) = P(AIE) \times P(BIE)$$

In words the equation may be read as: the truth of the probability of event A and B occuring, given the condition E, equals the probability of the truth of event A given E times the probability of the truth of event B given E.

The following appeared in Cowan to illustrate the application of such logic techniques in the study:

> "If statement A equals the supply of a resource and B the demand for the resource, then at a point where the truthfulness of statement A has a probability equal to 0.70 (that is, the probability of no supply in the study area = 0.30) and the demand equals 0.70 (probability of occurrence of an organism at the point taken as a percentage of the total population), the ecological importance of this study point would assume the value 0.49 (P(ABIE) = P(AIE) X P(BIE)). Whereas at another point with a supply of 0.70 and a demand of 0.20 by the organism, the value is 0.14 indicating the greater importance of the former."

In this way, habitats or resources in limited quantities would attain very high values.

Cowan compared two alternative situations: the existence of a river (as present) and the existence of a lake (as proposed). In each situation, the quantity of the resource was indicated and quantities of habitat assessed in terms of their amount and preference by different wildlife groups. Data was collected at the nodes of 1/4-mile grid squares, with each node designating an environmental value based on the probabilities of supplies and demands for each of five study categories. Two of the categories represent human activities and three represent faunal concerns: agriculture, recreation, habitat for large mammals (deer), habitat for birds, habitat for fish. For each category several classes of supply and demand were defined. The results indicated that the Platte River Dam would not have as adverse an impact as other studies had suggested. The lake was more desirable than the river for three of the five evaluation categories: birds, recreation, and fish.

Cowan concluded that the technique is useful for objectively assessing environmental change from either a human or an organism preference. He also pointed out the flexibility of the technique, that any desired number of study categories and classes of supply and demand could be accommodated.

Carlisle and Park (1976). These researchers conceptualized and programmed a predictive model for land use change and impacts (Carlisle and Park, 1976) and illustrated some aspects of its application through a case study of a wastewater treatment facility (, 1976). The importance of the model lies more with the philosophy it presents than in its outputs because much of it was not implemented in the case study. The work represented a part of the overall effort to develop an ecosystem oriented methodology for space-time analysis (Jameson, 1976) as diagrammed in Figure 12. The general approach attempted in ecosystem models is shown in Figure 13; information from diverse sources is used to make projection of land use, ecosystem response, and incremental and synergistic effects. As yet, such models are still under development.

The model, called LAND (for Land-use Analytical Descriptor) was based on the following concepts: (a) that land use changes are driven by established trends and additional infrastructure investment, (b) that changes are mediated by site characteristics, and (c) that changes influence the function of natural and agricultural ecosystems. The model adapted the land use transfer approach of Hett (1971) and assumed that a certain hierarchy of types of land use and vegetational succession transfers would occur. For each transfer, a mean transfer rate was assumed and the transfers calculated by a set of simultaneous differential equations. For the Lake George study, the model was calibrated for 20 years (data base consisting of three sets of data at ten-year intervals) and was considered to be capable of calculating reasonable land use transfers over a 50-year projection period.

The model was to include routines that would linearly transform land use categories and forest types to animal habitats so that the presence or absence of certain species could be projected. The basic assumption of these

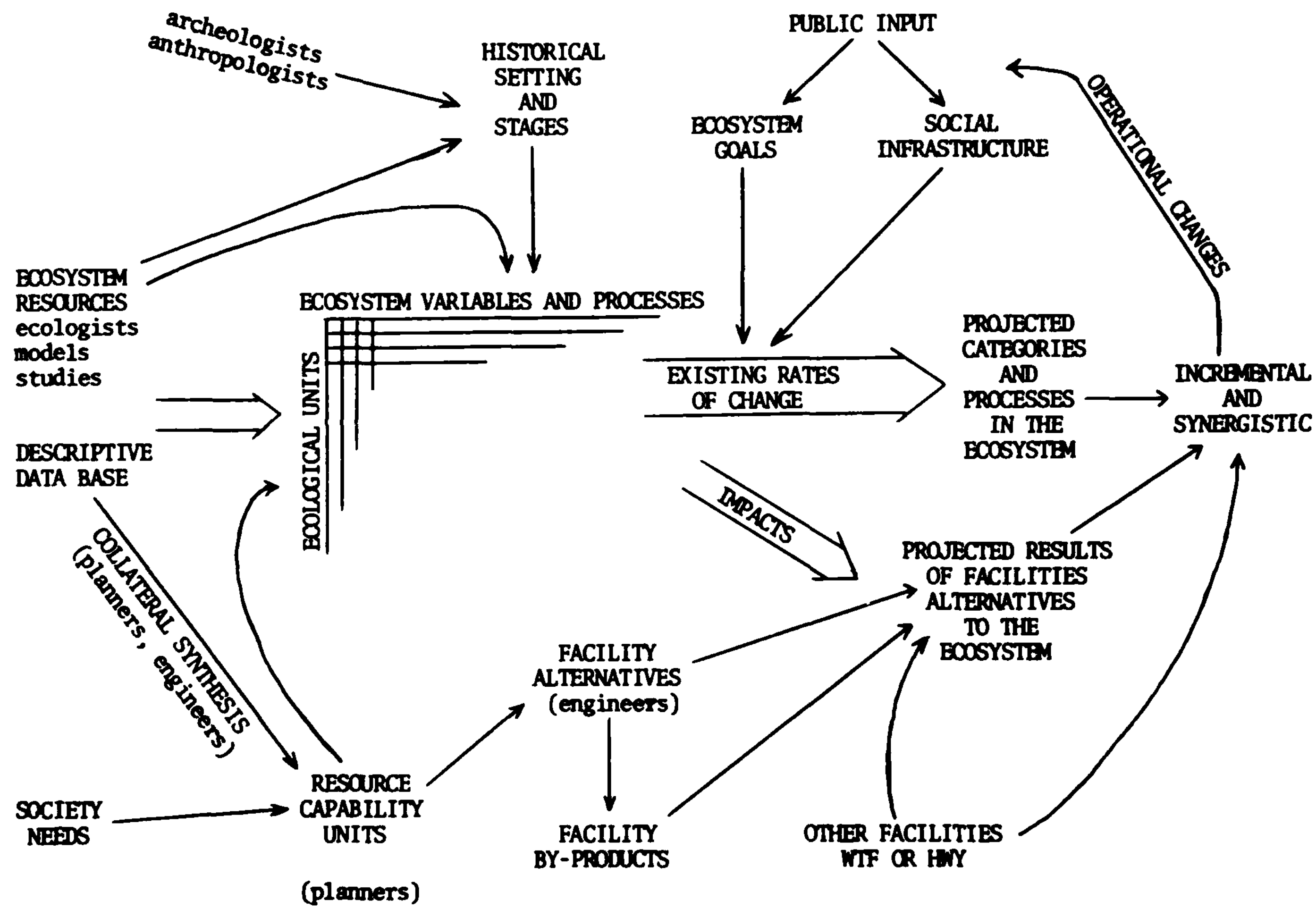


Figure 12. Diagram of procedural flow for conducting space-time analysis. (From Jameson, 1976)

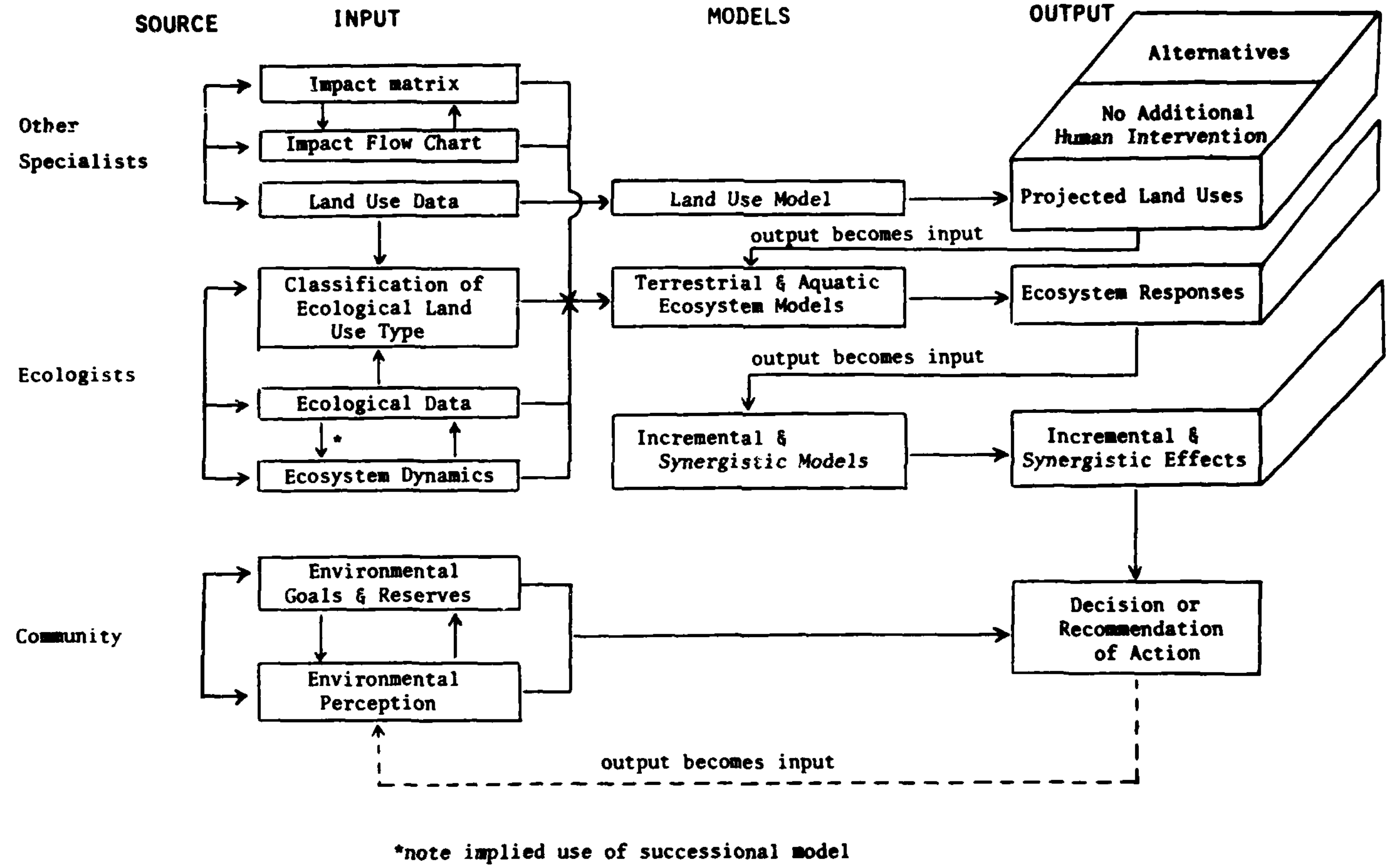


Figure 13. General approach of ecosystem models.
(From Jameson, 1976)

transformations was that the presence of required habitat implied the presence of the species, except in the case of deer or other heavily limited wildlife. The researchers stated that by using information from state wildlife biologists as to species habitat preferences, requirements for habitat contiguity, and tolerance of man, that it would be a straightforward programming task to transform predicted land uses and forest types into species-specific habitats. They assumed that even a mix of cover and feeding types could be considered as a linear combination of land-use and forest-type characteristics. However, the case study did not include the species habitat transformations.

Fabos, Greene, and Joyner, (1978). Since the early 1970's, a group at the University of Massachusetts has been developing a comprehensive approach to regional land use planning. The efforts are collectively titled METLAND (for metropolitan landscape) and are directed at techniques for assessing the potential cause-effect relationships of alternative land uses on various landscape, ecological, and public service resources of prime concern in landscape planning. METLAND is actually a system of techniques, at various levels of development, which are organized into three major phases (Figure 14): (a) composite assessment of significant landscape attributes, (b) formulation of alternative planning scenarios, and (c) evaluation.

The METLAND approach for projecting land uses is within the context of landscape planning. The description of future uses then is essentially that of the most suitable and desirable usage rather than the most probable. Although the overall approach is not directly applicable to the activities in the Corps planning tasks, some of the concepts and individual techniques, as for scenario development and impact assessment, are of interest. Of particular interest here is the procedure for wildlife productivity assessment. Table 25 lists the steps.

The wildlife assessment technique in METLAND rests on two basic assumptions. First, that the quality of wildlife habitat is controlled by many factors but most obviously by adequacy of food and cover, which, in turn, are directly dependent on the soil. Therefore, an assessment of the wildlife productivity potential of land can be inferred in a way similar to determining agricultural potential, i.e., by assessing the inherent suitability of the soil for developing or maintaining wildlife habitat. Second, that the overlying land use may offset the wildlife potential, and that the degree of detraction is associated with the land use. Also, the technique recognizes that habitat can be classed in three essentially exclusive categories: openland, woodland, wetland. After determining the wildlife productivities for each habitat category, the grid cell maps are overlain and a composite map produced.

Miller, Tom, and Nualchawee (1977). This report describes the development and applications of a landscape model to predict how the landscape will spatially evolve into various alternative scenarios (Figure 15). The model was of interest to this review because of its relative simplicity and long projection period: 576 sq. miles of the rapidly expanding Denver urban area were modeled in 10-acre, grid cells using only 34 landscape variables (Table 26) to spatially project 24 land use categories (Table 26) at 16 time periods over more than a 100-year period.

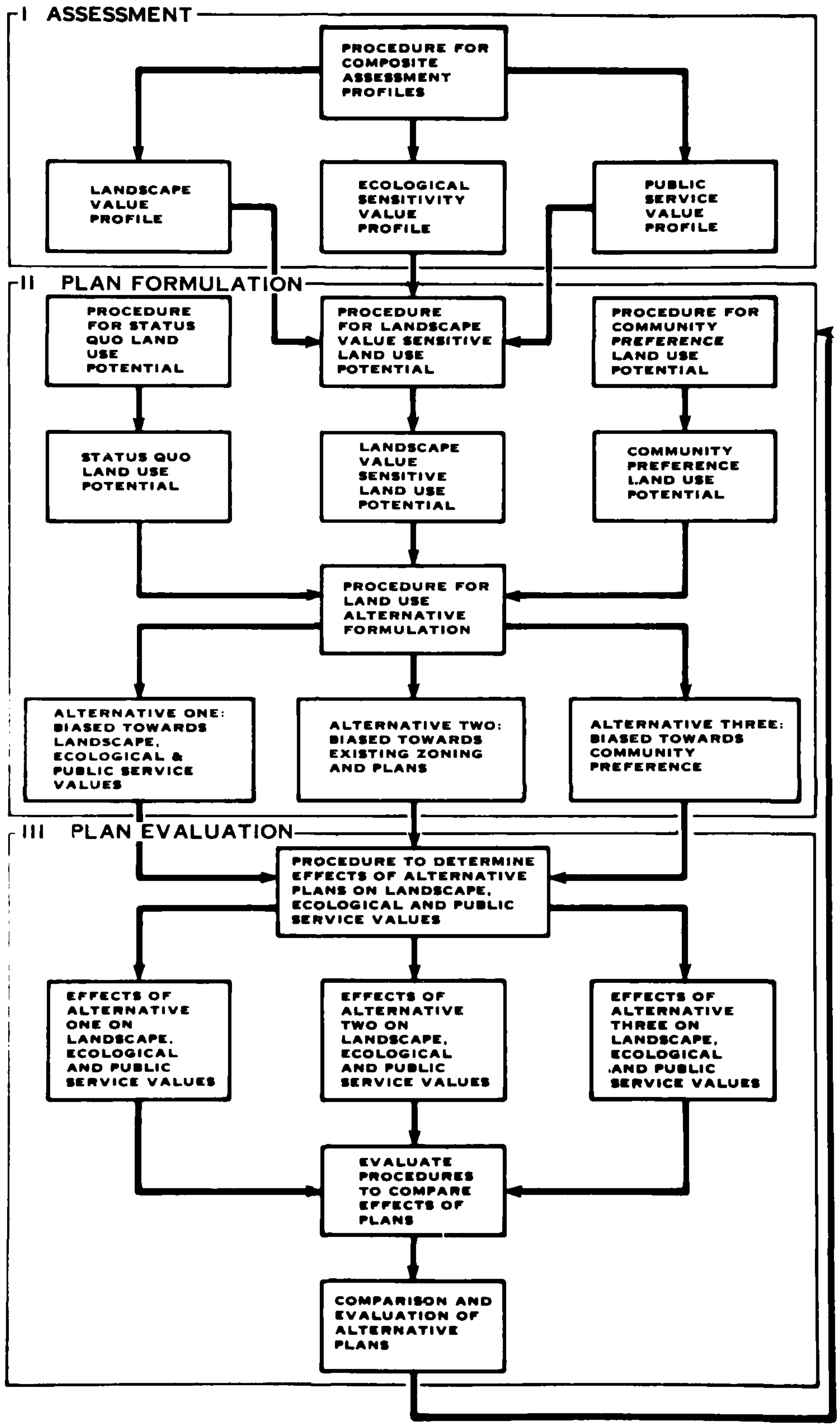


Figure 14. The METLAND planning process flow diagram. (From Fabos, Greene, and Joyner, 1978)

Table 25

<u>Steps in the METLAND Wildlife Productivity Assessment Procedure</u>
(From Fabos, Green, and Joyner, 1978)

(Step 1) The soil types are grouped into four suitability groups (with respect to one of the habitat types, e.g., openland) and each group is assigned a positive rating (+25 to +100). Then using the 0.3 acre COMLUP grid, an aggregate solid map is produced on magnetic tape.

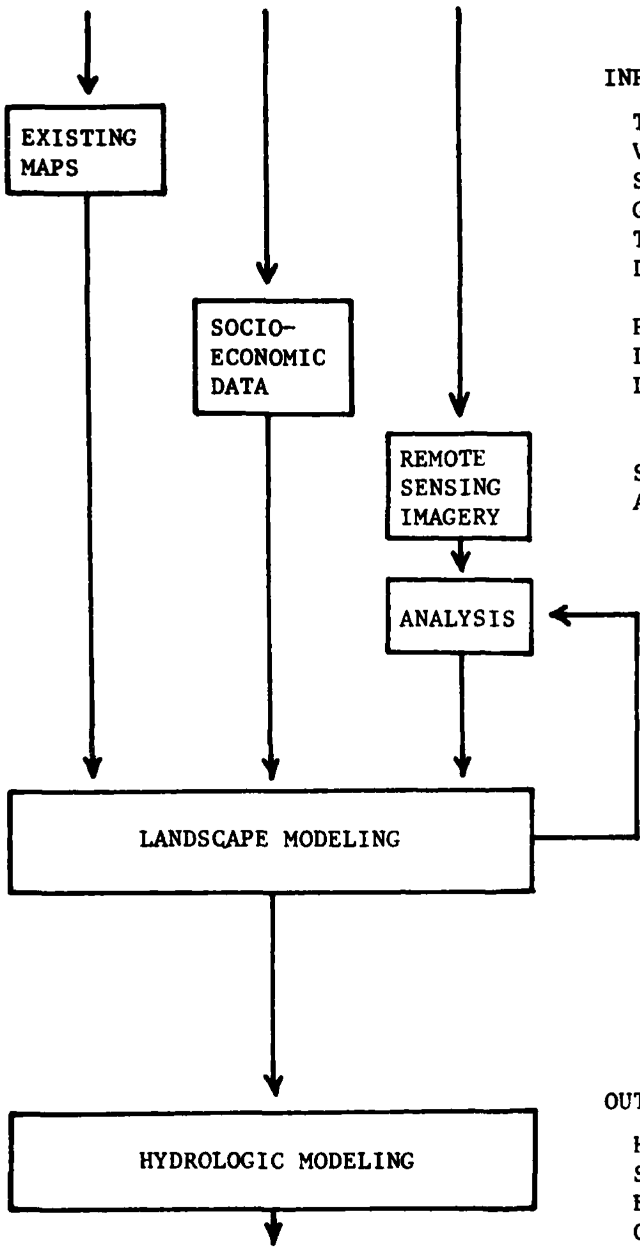
(Step 2) All land uses are grouped based on the degree to which they are likely to detract from the suitability of the soil. These groupings are rated 0 to -100, and are used to produce an aggregated land use map on magnetic tape.

(Step 3) The two aggregated maps are overlaid. A final wildlife productivity rating for each cell in the grid is determined by subtracting the land use detractor rating for that cell from the soil rating. The final combined ratings are grouped into three classes and an A-B-C map for the resource is produced. (Note, this process is programmed in one integrated operation.)

<u>Comments</u>. It should be emphasized that this technique measures potential, not necessarily actual, productivity of wildlife habitats. Vegetative edge diversity, while recognized as potentially important, has not been incorporated into the technique, primarily due to the unavailability of source data.

Finally, the research team feels that the technique for wildlife productivity, as currently developed, rates the following validity estimates*:

hardness of data used	- Medium
completeness of technique	- Medium
accuracy of parcel boundaries	- High
purity of parcels	- High
accuracy of overlays	- Low



INPUTS:

Topographic Maps
Vegetation Maps
Soils Maps
Geologic Maps
Transportation Maps
Drainage Maps

Population Maps
Landownership Maps
Land Value Maps

Satellite Images
Aircraft Images

Photo Interpretation
Computer Classification

COMPUTES:

Slope, Aspect Planes
Minimum Distance Planes
Surface Routings Planes
Solar Insolation Planes

Higher Order Computations
Current Landscapes
Projections of Alternative Landscapes

OUTPUTS:

Hydrogram Simulations
Siltation Yields
Erosion Maps
Optimal Sites of Major Structures and Many Others

Figure 15. Simple schematic representation of the landscape modeling concept. Spatially referenced data from a variety of sources is overlaid in the landscape model. A symbiotic relationship exists between landscape modeling and remote sensing analysis. Current and projected landscape scenarios provide new inputs to the hydrologic modeling and decisionmaking process. (From Miller, Tom, and Nualchawee, 1977)

Table 26

The Landscape Variable and Land Use Categories Used by Miller, Tom, and Nualchawee (1977) to Model Future Spatial Land Use Change in the Denver Urban Area

Landscape Variables(34)

TRANSPORTATION SUBMODEL, VARIABLES:

- Minimum Distances to Low-Capacity Minor Roads
- Minimum Distances to High-Capacity Major Roads
- Minimum Distances to Freeways
- Minimum Distances to Freeways Inter-Changes
- Minimum Distances to Fully Developed City Streets

LAND USE SUBMODEL VARIABLES:

- 1963 Photo Interpretation of Land Use
- 1970 Photo Interpretation of Land Use
- 1973 USGS Photo Interpretation of Land Use
- 1963 Land Uses Lost to 1970
- 1970 Land Uses Gained from 1963
- 1963-70 Alphanumeric Land Use Change

SOCIO-ECONOMIC SUBMODEL VARIABLES:

- 5 Population/Family/Housing Unit Totals
- 1969 Mean Family Income
- Median Housing Unit Value/Rent
- 1, 2, 3, 3+ Car Families
- Census Tract Acreages
- 4 Population/Housing Densities per Acre
- Average Number of Cars per Family

PHYSIOGRAPHIC SUBMODEL VARIABLES:

- Topographic Elevation
- Topographic Slope
- Topographic Aspect
- LANDSAT Image Insolation
- Surficial Geology

Land Use Categories*(24)

AGRICULTURAL LANDS
- Cropland, Nonirrigated
- Cropland, Irrigated
- Pasture

URBAN LANDS
- Commercial and Services Area
- Extraction - Pit, Quarry, Strip Mine
- Recreational - Park, Golf Course, Drive-In Theater
- Cemetary
- Industrial
- Open Land - Vacant Land in Built-up Areas
- Public and Institutional - Schools, Federal Reservations
- Residential - High and Low Density
- Transportation Area - Airports, Railroad Yards, Interchanges
- Utility - Sewage Plant, Power Plant, Antenna Field
- Solid Waste Dump - Land Fill

FORESTED LANDS
- Coniferous, Intermittent Crown
- Coniferous, Soild Crown
- Deciduous, Intermittent Crown

WATER AREAS
- Streams and Canals
- Lakes
- Reservoirs

RANGE LANDS
- Chaparral
- Grassland

BARREN LANDS
- Hilly Slopes - Nonforested or Sparsely Timbered
- Exposed Rock - Sparse Vegetation

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*With these 24 categories, statistically there are 24^2 or 576 possible classes of transition; however, in actuality some would never or seldom occur (e.g., industrial to agricultural). For the Denver model study only 38 out of 576 were considered reasonably possible.

The reason the model is fairly simple is that it assumed that future changes in land use can be measured in terms of those which occurred in the recent past (in the Denver example the recent past consisted of two data bases separated by 13 years). As the report points out, its assumption does produce unrealistic predictions; the model could continue to project land uses over an unlimited projection period, but the accuracy of representing actual changes decreases. However, the authors believe that in that accurate predictions cannot be made and because techniques have not been perfected for introducing events not evident in the past, then the Markov trend model produces results which are useful and appropriate for gross interpretation.

Asherin, Short, and Roelle (1979). These researchers developed and tested a method for predicting and evaluating wildlife habitat quality. Although the method was developed for use on a regional scale to aid in identifying areas suitable for coal resource development, it could probably be calibrated for application in smaller areas. Also, even though the predictions made were spatial (i.e., for areas that had not been sampled), the methods may be adjustable for making predictions over time because the habitat parameters used related to cover type and cover type distribution. The method is briefly described here because it appears to offer potential in projecting future wildlife conditions and because it can be applied fairly quickly and easily. Figure 16 depicts the procedure. The method's assessment of wildlife habitat quality is based on two assumptions:

a. Habitat quality is a direct function of habitat diversity for the majority of terrestrial vertebrate species;

b. Characteristics that contribute to the diversity of wildlife habitat (such as interspersion of different vegetation or cover types, canopy cover of particular types, vegetative strata present, quantity and quality of edge between vegetation types, presence and distance to water, and unique physical features like cliff faces) can be assessed from aerial photography.

The basic data base for the procedure included the number of vertebrate species that breed within each cover type and the following habitat parameters obtained from aerial photography:

a. the number, identity, and area of cover types per section (sections are the legal divisions of land in the Montana test area);

b. the number of mapped polygons per section (a polygon was not defined, but appeared to refer to units of mapped cover type of a minimal area of 40 acres);

c. linear amount and identity of edge segments per section; and

d. proportion of each section occupied by individual cover types.

These data were used to calculate the following habitat variables:

a. Habitat strata diversity index;

b. Habitat cover type diversity index;

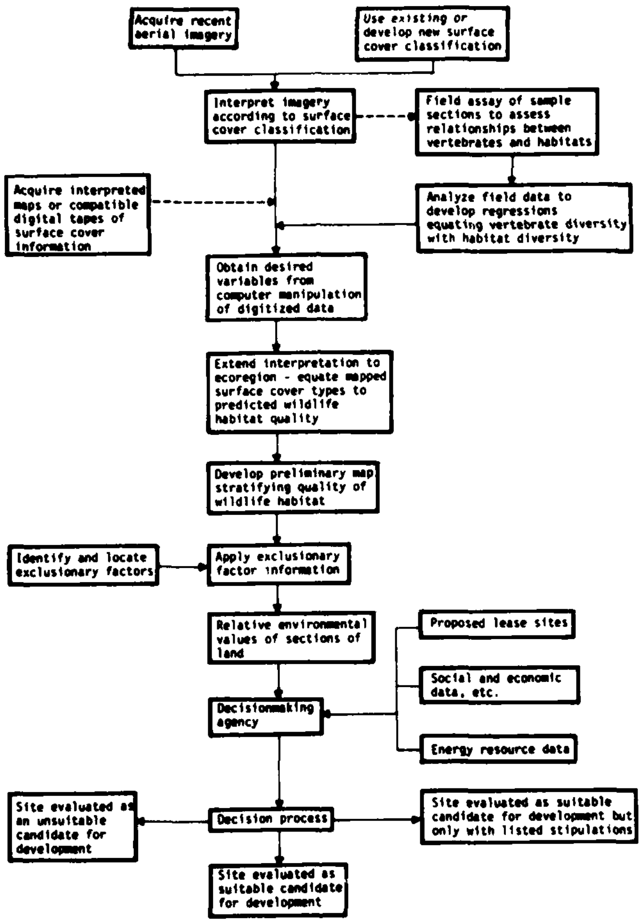

Figure 16. Flow chart depicting procedure for evaluating regional wildlife habitat quality and how this information might be used in the land use planning process. (From Asherin, Short, and Roelle, 1979) Reproduced with the permission of the Wildlife Management Institute, Washington, D.C.

c. Miles of edge per square mile;
d. Juxtaposition index, a relative measure of the quality of habitat edge calculated by summing the products of the length of each edge type in the section multiplied by the number of vertebrate species breeding in the cover types that make up the edge;
e. Faunal diversity index, a summation of the products of the area of each cover type in the section multiplied by the number of vertebrate species using that type for breeding.

Additional data was obtained through breeding bird surveys; this field work yielded values for bird species diversity (Shannon - Weaver formula), number of bird species, and number of bird life forms.

Using multiple regression analysis, in which the bird survey data were the dependent variables and the habitat data were the independent variables, it was determined that the most efficient predictor of potential wildlife habitat quality was the correlation of bird species diversity with the habitat strata diversity index and the habitat cover type diversity index ($r = 0.74$).

Based on this information, lands were stratified using the bird species diversity prediction equation. In this test case, areas with a bird species diversity of less than 60% of the maximum value were considered to have poor habitat quality while areas with more than 85% of the maximum were considered as high quality habitat. A display of the average of other variables in habitats defined on the basis of bird species diversity as having high, medium, and low quality is shown on Table 27.

Potter and Kessell (1980). Potter and Kessell describe a technique for predicting community mosaics and wildlife diversity in the aftermath of a forest fire. The approach is based on pattern recognition and applies an algorithm that delimits the size and shape of each patch from gridded data and than calculates standard diversity measures for the entire mosaic of community patches. The program also includes a routine for mapping habitat type by age class and for mapping the potential for specified wildlife species for using each grid area. The diversity indices and maps are produced for any desired time period. A feature of the technique is its flexibility: e.g., the grid size can be adjusted to the resolution desired, and diversity estimates can be made for selected species or species groups.

The land uses considered are habitat types differentiated by cover and age classes. Social and economic factors of change are not considered but information on the nature of post-disturbance environmental succession is a key input.

Examples of the output, using a 9.9-acre grid resolution, are shown on Table 28 and Figure 17. In this example, the total st[illegible] area is 632.6 acres in the Lewis and Clark National Forest of Montana. To [illegible] the model, an intensive fire over 23% of the area was simulated and pos[illegible]isturbance conditions at 0, 10, and 50 years after the fire were estimated.

For this particular example, an unusually good and extensive data base on the potential habitat use for feeding and reproduction of 489 species of birds

Table 27

Mean Ecological Characteristics of Areas Determined, on the Basis of Bird Species Diversity, to be of High, Medium, and Low Wildlife Habitat Quality

(After Asherin, Short, and Roelle, 1979)

Ecological Characteristics	Wildlife Habitat Quality		
	High	Medium	Low
Number of Polygons	25	12	3
Number of Cover Types	8	5	3
Miles of Edge/Sq Mile	11.1	6.2	2.8
Habitat Strata Diversity	1.07	0.67	0.04
Habitat Cover Type Diversity	1.71	0.94	0.41
Measured Bird Species Diversity	2.65	2.12	1.76
Predicted Bird Species Diversity	2.59	2.12	1.59

Table 28

Example of Information Obtainable from the Model Developed by Potter and Kessel (1980) for Predicting Community Mosaics and Wildlife Diversity
(From Potter and Kessell, 1980)
Reproduced with the permission of Springer-Verlag New York, Inc.

Diversity of the habitat-type age-class mosaic, potential bird feeding and reproduction habitat utilization, and potential mammal feeding and reproduction habitat utilization for the predisturbance community and the postdisturbance community at ages 0, 10, and 50 years

Dimension	Predisturbance	0 Years Postfire	10 Year Postfire	50 Years Postfire
Community Mosaic				
H'	2.06	2.23*	2.23*	2.23*
$e^{H'}$	7.83	9.34*	9.34*	9.34*
C	0.146	0.126*	0.126*	0.126*
1/C	6.87	7.91*	7.91*	7.91*
Bird Feeding				
H'	5.18	5.18	5.47	5.31
$e^{H'}$	177.	178.	237.	203.
C	0.006	0.006	0.005	0.006
1/C				
Bird Reproduction				
H'	4.65	4.75	5.02	4.75
$e^{H'}$	104.	116.	151.	116.
C	0.010	0.010	0.007	0.010
1/C	95.7	103.	135.	102.
Mammal Feeding				
H'	4.09	5.62	5.46	5.31
$e^{H'}$	59.7	276.	236.	202.
C	0.019	0.004	0.005	0.006
1/C	53.9	240.	208.	174.
Mammal Reproduction				
H'	4.77	4.74	5.00	0.73
$e^{H'}$	118.	115.	148.	113.
C	0.009	0.010	0.008	0.010
1/C	106.	99.8	128.	97.1

*Value retained in absence of further disturbance.

H' = Shannon Weaver diversity index
$e^{H'}$ = Exponent Shannon Weaver
C = Simpson Index
1/C = Reciprocal Simpson

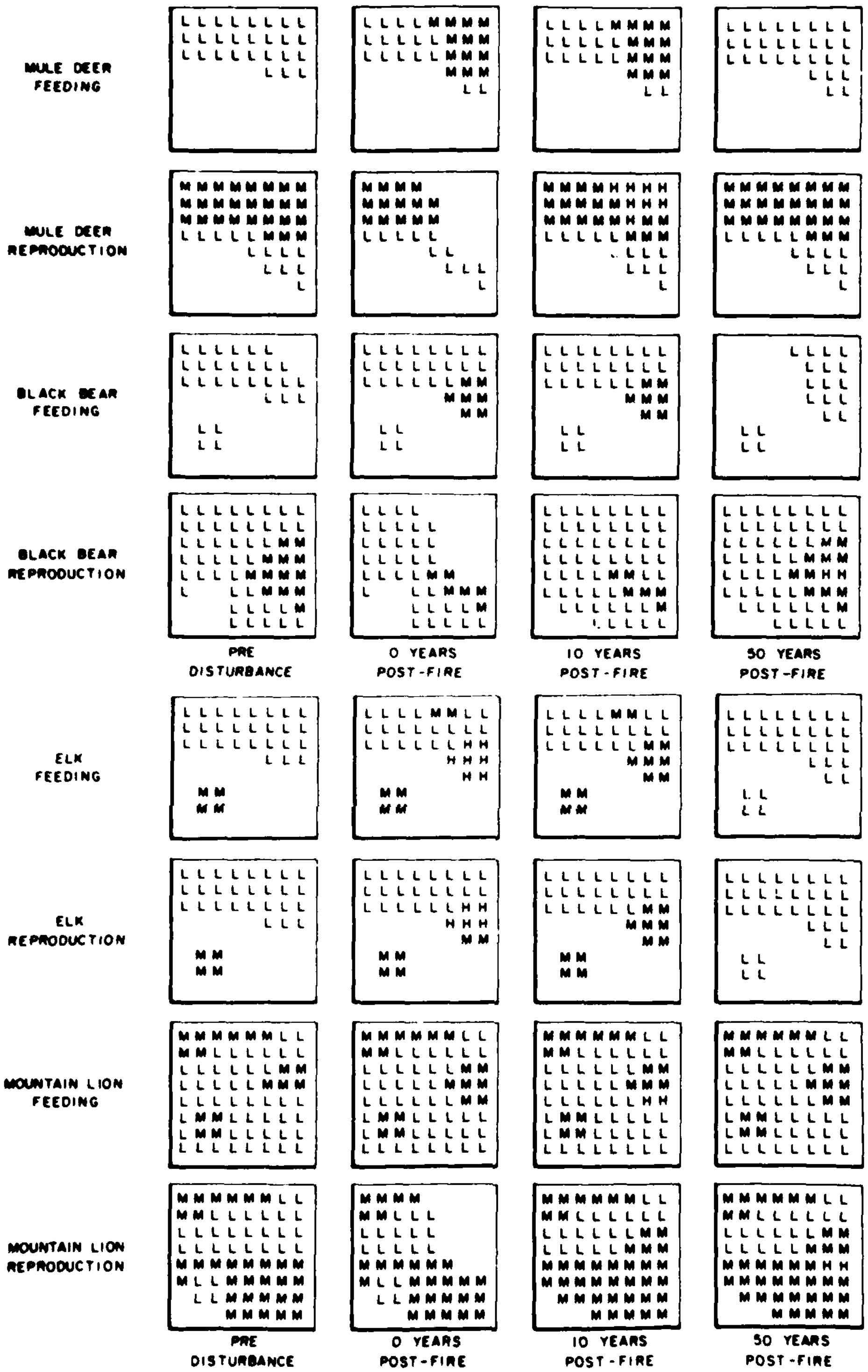

Figure 17. Example of computer-mapped output from the model developed by Potter and Kessell (1980) for predicting community mosaics and wildlife diversity. (From Potter and Kessell, 1980) Reproduced with the permission of Springer-Verlag New York, Inc.

and mammals was available. The data needed to apply the model in other areas would depend somewhat on the desired level of planning. Although the authors do not indicate what the minimal data requirements would be, the technique offers potential as a tool for anticipating impacts as well as developing a wildlife management plan.

Studies Reported in Corps Planning Documents

The effort to obtain an overview of approaches that have been used for anticipating changes induced by water resources development included a review of several Corps planning studies. Candidates for study were identified by contracting district and division planners and asking them for information on what assumptions, procedures, or criteria are actually applied for projecting with and without project land uses or land cover and, more specifically, how those futures are analyzed in terms of their condition for wildlife. In response, most recommended that the best way to acquire this information would be to work through recent planning documents. Of the planning studies which were recommended, those that appeared to give the most consideration to projecting land use and wildlife futures were selected for close examination (Table 29). Table 30 provides an overview of the key elements of each of the studies reviewed.

General approach

Discussions with planners and review of the material they provided indicated that in a broad sense there is a commonly applied approach which is consistent with the phases of the Corps planning process. Initially, the resources and their use are inventoried and available data on their historical condition is collected. Then, the existing land use patterns are analyzed with particular attention given to the environmental, economic, and cultural reasons for their development. The resource and land use information provides a profile of the study area and its relationship to the regional setting that is the basis for conducting the planning study.

Once the profile is compiled, then work can be begin to describe future conditions. This effort is accomplished through coordination with regional and local planning agencies, and State and other Federal organizations. Key considerations in developing futures are the physical capabilities of the land, economic conditions, development demand, and land control. The kinds of assumptions and perceptions about the future are related to the existing setting of the study area.

If the project is in an isolated rural area with productive soils and gentle topography, then it is reasonable to assume that existing types of agriculture will continue and expand in the future. If the area is rural but in proximity to an urban center or a major highway, then some extent of urban development can be expected unless there are obvious natural or cultural controls against it. In general, if an area is agricultural, then the following are reasonable assumptions for developing projections: (a) openland areas will continue to be grazed or cropped if practical and profitable; (b) woodland will decrease if the demand for the agricultural products which it

Table 29

Field-recommended Planning Studies which were Reviewed In-depth In Order to Identify the Methods and Assumptions Used for Projecting Future With and Without Project Conditions

Field Office	Planning Study	Type of Project	Documents Studied
New England Division	Dickey-Lincoln School Lakes	Hydropower and flood control (multipurpose impoundment)	U.S. Army Engineer Division New England (1977, 1978)
Wilmington, District	Wilmington Harbor, Northeast Cape Fear River	Navigation	U.S. Army Engineer District, Wilmington (1979)
St. Paul District	Twin Valley Lakes	Flood control (multipurpose impoundment)	U.S. Army Engineer District, St. Paul (1979) U.S. Fish and Wildlife Service (1978)
Louisville District	Big Blue Lake	Flood control (multipurpose impoundment)	U.S. Army Engineer District, Louisville (1978, 1979)
	Louisville Lake	Flood control (multipurpose impoundment)	
St. Louis District	Union Lake	Flood control (multipurpose impoundment)	U.S. Army Engineer District, St. Louis (undated)
Sacramento District	Marysville Lake	Multipurpose impoundment	U.S. Army Engineer District, Sacramento (1976, 1977, 1978, 1979)
	Cottonwood Creek	Multipurpose impoundment	State of California, Dept. of Fish and Game (five reports, 1979)
Galveston District	Freeport Harbor	Navigation	U.S. Army Engineer District, Galveston (1978)
Fort Worth District	Rowlett Creek	Expanded flood plain information study	U.S. Army Engineer District, Fort Worth (1978, 1980)
	Walnut-Williamson Creeks	Expanded flood plain information study	

Table 30

Overview of Elements of Planning Studies Surveyed

Study	General Setting	Study Period, Years	Target Years	Designated Habitat Types	Designated Land Use Types	Future Without Project (Expected Change from Baseline)	Future With Project	Treatment of Wildlife
Dickey-Lincoln School Lakes	Remote, forest	100	1, 10, 30, 100	10	6	Insignificant; trend projections; increased forest management	Zoning increased extended; forest harvest affected	Value of habitat to selected series
Wilmington Harbor, NE Cape Fear River	Undeveloped, near expanding industrial	50	0, 50	6 ecosystem types - from urban to marsh		Growth rate to would become developed	Significant wetland area would be protected	In terms of indication of env. qual; habitat diversity, rarity, game value
Twin Valley Lake	Agricultural	100	0, 5, 10, 20, 50, 100	9	0	Increase in cropland, no change other habitat types	Project induced natural succession and land loss	Value of habitat to selected species
Louisville Lake	Rural	100	0, 25, 50, 75, 100	9	0	Areas with potential for agriculture will convert.	Changes direct from project development and	Habitat value for representative species;
Big Blue, Lake	Rural	100	0, 25, 50,	9	0	No change in habitat type quality	operation (recreation, water fluctuation)	esp. as affected by change in quantity and disturbance
Union Lake	Agricultural	45	0,45	6	0*	Normative growth. No change in habitat type quality	Habitat value decrease due to inundation, recreation, off-project land use changes	Habitat value for wildlife in general, not specific to species

(Continued)

(Table 30, Continued)

Study	General Setting	Study Period, Years	Target Years	Designated Habitat Types	Designated Land Use Types	Future Without Project (Expected Change from Baseline)	Future With Project	Treatment of Wildlife
Marysville, Lake	Agricultural	100	0, after 25, after 50	6	7	Land use changes based on population projections and regional perspective	Similar to future without except for Federal acquisision and lake recreation	Carrying capacity of wildlife groups as affected by disturbance, veg. cover
Cottonwood, Creek	Agricultural	100	0, after 13, after 63	5	20	Three scenarios; tentatively the most probable describes minimal well-planned growth	Similar to future without except for Federal acquisition, lakes, and lake-induced development	Carrying capacity of wildlife group as affected by disturbance, veg. cover
Freeport Harbor	Commercial Urban	50	0, 10, 20, 30, 40, 50	4	0	Significant	Creation new disposal area; succession on disposal area after abandonment	Value of habitat to wildlife groups; judgemental relationship between habitat quality and wildlife abundance
Rowlett Creek	Rural	NA**	NA	10	22	Conceptual future is 70% urban; existing is 20 % urban. Computerized overlay of future on existing yield acreage loss or gain and location of land use change		In terms of habitat acreage loss or gain and species associated with habitat types

(Continued)

(Table 30, Concluded)

Study	General Setting	Study Period, Years	Target Years	Designated Habitat Types	Designated Land Use Types	Future Without Project (Expected Change from Baseline)	Future With Project	Treatment of Wildlife
Walnut and Williamson Creeks	Rapidly urbanizing	NA**	NA	14	19	Conceptual futures up to 73 and 86% urban; existing is 30 to 36% urban. Analysis of futures similar to Rowlett Cr.		Value of habitat to selected species. Value discounted with increased proximity to urban activities

* Projected reservoir-induced residential development on off-project lands.

** Expanded floodplain information study; analyzed five land use conditions representative of a range of development conditions.

could produce is expected to increase; (c) fence rows will be sprayed or mowed except where terrain is too steep to justify the effort.

If the project is in an urban area, it can generally be assumed that urban or industrial development will expand. The type, direction, and intensity of such development will be somewhat related to the social character, political climate, and environmental ideals of the community. For example, a strong park commission, influential academic community, and preponderance of affluent white collar workers are factors which favor the choice to preserve natural areas. In areas where natural areas are valued for their cheap opportunity for development, then their transformation to some urban use can be expected.

Some assumptions about future conditions are obviously regional. For example, much of the Pacific Northwest is in large contiguous areas of National Forest, or in corporate ownership for timber or pulp paper production, or is either so far removed from urban centers or topographically unsuited for development, that it is reasonable to expect that future without conditions will essentially be the same as existing conditions. In the midwest and eastern United States, natural areas are decreasing and the trend is likely to continue. In wheat production areas, the politics and economics of wheat sales are significantly correlated with waterfowl habitat conditions.

While this describes the general approach and some major assumptions, the actual details of the futures development and analysis are rooted in study-specifics including the type of project and the peculiarities of judgement and informed opinion that are applied. It is the particular combination and interaction among the study-specific variables that underlie the procedural differences a Corps office may take in planning a particular project. The review of planning documents and other information from the field indicated that the major variables are:

1. Project setting. The geographic, ecologic, demographic, economic, and cultural characteristics.

2. Level of information available on existing and historical conditions.

3. Identification of important factors. This is obviously governed by the project setting, but the degree of refinement and sophistication in discerning what is important to consider varies with the understanding of that setting.

4. Conscientiousness and perception of the field office with respect to:

   a. interpretation of interrelationships among the important factors (this is based on the assumption developed and the criteria used),
   b. interpretation of the requirements of the planning process.

5. Spatial detail of the analysis. This varies from the finite, which considers many land use and habitat categories studied through

computerized analysis of grid-cell data or large-scale overlay mapping, to the gross in which few categories are considered and smaller-scaled maps are used.

6. Target year intervals. This can vary from no interval (or use of existing conditions), to target years spaced evenly over the life of the project, to target years concentrated within the first third or half of the life of the project where projection confidence is greatest.

7. Agency Coordination. With respect to the identification of important factors, the North Central Division (Personal Communication, 15 August 1979, Alfred Behm, Chief, Planning Division, U.S. Army Engineer North Central Division, Chicago, Ill.) identified the interrelated factors which are key in evaluating without project conditions for wildlife habitat (Table 31). As indicated in the listings, the factors vary by project type and setting; however, politics and economics are shown to be important influences on habitat in any circumstance.

Case study approaches

Although in a general sense the eleven case studies exhibited a similar approach, which has just been described, a closer consideration shows that there are variations in the procedures for projecting land uses and environmental conditions and for analyzing these conditions. Some aspects of these variations are summarized in this section. Appendix A provides a synopsis of each of the case studies, including major assumptions and information on how land use projections, project impacts, and wildlife were treated.

Dickey - Lincoln School Lakes. The study area is located in a fairly remote and relatively undisturbed area. Projections were made over the 100-year life of the project, but in that little disturbance or change was expected to occur without the project, the most probable future was assumed to be essentially the same as for existing conditions. For wildlife, it was assumed that habitats are presently occupied at or near maximum equilibrium population and would continue to be occupied at that level unless the habitat was drastically changed.

The proposed lakes would result in a drastic change and the impact on wildlife was assumed to be directly related to the acreage inundated. For example, in that 20 percent of the area within the study area would be inundated, it was assumed that without wildlife management measures that there would be a 20 percent reduction in the standing crop of species with non-specific habitat requirements.

The 1976 HEP was applied for calculating the habitat loss that would be caused by the project and the acreage that would be needed for mitigating that loss. Using different assumptions, the HEP was applied both by the Corps and by the USFWS; the considerable difference in calculated mitigation need exemplifies the importance that selection of assumptions can have on results.

Table 31

Major Factors to Consider When Evaluating What Wildlife Habitat Conditions Might be Like If the Project is Not Constructed

(From material provided by the North Central Division, CE)

Reservoir Project		Local Flood Protection Projects	Agricultural Reserves
Rural Area	Urban/Rural Area		
• Surrounding land use patterns • Economic level of rural community (growth rate or decline) • Natural successional change of existing habitat • Type of crops or animal husbandry • Strength and/or weakness of other agricultural program (SCS etc.) • Juxtaposition of existing habitat types of relation to each other	• Existing land use patterns • Size and economic strength of urban area (expanding or declining) • Industrial development or potential for industrial development • Road and rail patterns in relation to project site • Natural successional change of existing habitat • Environmental attitude of urban and rural populus • Relationships between quality and quantity of habitat • Trends in urban development and direction of development • Recreational needs and demands	• Trends in urban or industrial development • Transportation network • Social attitudes • Natural successional changes • Land economics • Recreational needs and demands	• Agricultural economics • Trends in crop production • Frequency of flooding and duration • Potential for urban or industrial development (to include base economics of area and available work force) • Structure of local society

The approach for estimating HEP habitat values at various target years was simple: measured baseline values were adjusted up or down by a likely percent. The amount of adjustment was determined by experts through discussion as to the probable changes in habitat condition at each target year and their agreement as to the percent of change from existing conditions. Some unique aspects of the HEP application for determining mitigation requirements in the Dickey-Lincoln study are:

a. The determination of number of acres required to mitigate deer harvest as based on an approach in which the objective is to maintain, through management, the annual average harvest that is projected for without the project.

b. The adjustment of the HEP management potential value to account for the effect that the difference in before and after mitigation habitat interspersion would have.

Wilmington Harbor, Northeast Cape Fear River. The Wilmington Harbor study was concerned with the feasibility of an improved navigation channel. The area immediately upriver from the proposed improvements was essentially natural, consisting primarily of wetlands and upland forests which were either industrially owned or had high potential for development. The study's environmental analysis focused on the probable project-induced effects on this large natural area and developed an approach to anticipating the effect on environmental quality.

The development of the most probable future land use was based on historical land use change and assumptions about continued trends in those changes. For example, projections of economic activity were made on the basis of the historical correlation of relationships between growth of commerce, population, and personal income. Description of the most probable future was aided by the construction of a maximum and minimum development scenarios.

For both the with and without project futures, acreages were projected for Year 50. The impacts of the alternative plans on the without condition were assessed by estimating, under all alternative futures, the expected level of five ecological criteria: net primary productivity, energy flow, habitat diversity, rarity (endangered and threatened species), and game value. The wildlife treated in greatest detail were birds and game species. The number of bird species potentially present by habitat type yielded the measure of habitat diversity. Game value, calculated by habitat type, was determined by rating each habitat as to its value for cover (0-5 points) and food (0-5 points) for each selected game species. Once all five criteria were projected for each alternative and their values multiplied by the projected acreages, the alternatives were compared by calculating their percent deviation from the without project condition.

Twin Valley Lake. In this planning study for an impoundment in a predominantly agricultural area, it was assumed that any changes occurring over the 100-year projection period would be insignificant and therefore, the most probable future would be essentially the same as existing conditions.

A 1976 HEP analysis was employed to determine project impacts, but the procedure was modified in order to account for "indeterminable effects" such as habitat degradation resulting from pressures on resources and from recreational use. Adjustment for these effects was accomplished by calculating the number of habitat units that could be gained from management in the compensation areas and then reducing this gain by 40 percent. This included a contingency factor of 20 percent to account for lack of refinement and uncertainties in the study. The HEP application was also modified by the development of a compensation ratio so as to incorporate a critical factor assigned to habitat types having particular ecological value (e.g. deer wintering habitat). The ratio enabled a comparison of habitat units lost in the project with those gained in the compensation area.

Louisville Lake and Big Blue Lake. These rural studies were conducted using a similar approach which combined a modified HEP analysis (1976 version) with 100-year projections of expectable changes in existing habitat for both with and without the project.

Without project land use acreages were projected in 25-year intervals and were based on soil types, existing land use patterns, and economic and demographic trends. In particular, it was anticipated that agricultural lands would increase. The location of cropland increases was established by assuming that lands which would most likely convert to crops would be bottomland areas having high yield potential and located adjacent to cleared fields.

The HEP habitat quality values determined for existing conditions were of use in evaluating future conditions in both the without and the with project scenarios including the "new" habitat created with the project. For with project projections the habitat quality values were reduced by certain percentages in order to derive what was felt to be a more realistic value for certain habitat situations. For example, large areas of contiguous cropland were assumed to have less habitat value than the surrounding area, so their HEP-assigned values are reduced. Also, areas subject to recreation pressure and water level fluctuation would have reduced habitat quality, the actual percent reduction being dependent on the type of recreation activity and the frequency of inundation. Table 32 summarizes some of the assumptions used in establishing habitat quality values. Appendix B provides further details on the procedures employed to project land uses.

Union Lake. In this study, a probabilistic model was constructed to simulate future residential development on off-project lands around Union Lake. The model was based on the approach developed by Burby et al. in a series of reports (Burby, et al., 1970, 1971, 1972). The factors that were considered to be significant in stimulating residential development were: road distance to metropolitan area, peninsula location, aerial distance to shoreline, availability of public road, and lack of ground cover.

Future terrestrial habitat was evaluated by reducing existing HEP-determined habitat values by certain percentages. It was assumed that losses in habitat value would accrue through inundation, recreational

Table 32

Major Assumptions Applied to Alter Habitat Quality Values; Louisville and Big Blue Lakes (from U.S. Army Engineer District, Louisville, 1978 and 1979)

Habitat Situation	Criteria Considered in Assigning Habitat Quality Value
Lineal habitats, e.g. fencerows and streams	How much acreage the lineal habitat would cover if lengths of it laid out side by side.*
Total aggregation of cropland	Habitat value of all cropland in excess of 25% of the project area was devalued by 50%.
Roads and boat ramp areas	Habitat quality assumed to be zero
Campsites	Habitat values reduced by 10%**
Adjacent to game and play areas (i.e. within a zone twice the size of the recreation area)	Habitat values reduced by 5%
Water fluctuation frequency allows no vegetation	Habitat quality assumed to be zero
Water fluctuation frequency allows only tolerant grasses	Habitat value equal to 60% that of old field habitat
Water fluctuation frequency allows sapling-sized species	Habitat value equal to 70% that of old field habitat
Wetland	Habitat values assigned based on age of wetland

*The HEP-determined habitat quality values were increased by a factor of 3.4 and riparian habitat by a factor of 2.8 to account for their values as an ecotone.

**In the Louisville Lake, study, it was observed that a heavily grazed woodland displayed an overall habitat value about 10% less than ungrazed. A primitive camping area with limited tree removal and some clearing of understory vegetation was considered roughly similar to a grazed woodland.

Table 33

Judgmental Relationship Between Habitat Quality Value and Wildlife Abundance
(U.S. Army Engineer District, Galveston, 1978)

HEP Habitat Value Rating	Judgmental Recognition of Habitat Quality	Generalized Description of Habitat and Wildlife Abundance
0	Useless	Habitat will not support most forms of life
1–2	Poor	Poor habitat, unsuitable for most desirable species, organisms uncommon.
3–4	Fair	Marginal quality, organisms uncommon
5–6	Average	Moderate to variable quality, organisms fairly common or fluctuating in abundance
7–8	Good	Good quality, food and cover for many species, organisms common
9–10	Excellent	Very high quality habitat, excellent food and cover for most species, organisms abundant and diverse

development, reduced carrying capacity, and off-project land use changes. For example, it was assumed that the percent loss from existing conditions of habitat value of lands within the joint pool would be 98 percent; for flood pool areas inundated every two years the reduction would be 25 percent; and if inundated every five years, the reduction would be 10 percent. Similarly, in areas projected for intensive recreation immediately after impoundment, existing habitat values would be reduced by 25 percent because of recreational development and disturbance. The synopsis in Appendix A details the assumptions and procedures for accomplishing the future development and habitat evaluation.

Marysville Lake and Cottonwood Creek. Reports for these planning studies clearly evidenced the rationale for developing the most probable future. Description of future conditions was based on local and regional population projections and the land use change they would induce. Description of future plant community conditions took into account anticipated land use changes, recreational use, water use, and successional stages. Description of future wildlife conditions was based on anticipated changes in plant communities. For some species, workable estimates of population changes were developed through consensus of expert judgment although the inherent assumptions were not clear: for example, for deer in the Marysville Lake Study, estimates of 7.5 percent reduction in 25 years and 15 percent reduction in 50 years were used. As in the Wilmington Harbor study, an important part of these studies was the development of future growth scenarios. Appendix B provides the assumptions and land use implications of scenarios developed for the immediate project area in the Cottonwood Creek study.

Of the planning documents reviewed for the survey of approaches used, Marysville Lake and Cottonwood Creek presented the most comprehensive study of regional and local factors, their anticipated changes, and the anticipated impacts on wildlife groups and species. Appendix B contains a procedural outline for the projection of land use and wildlife for both with and without conditions in the Marysville study. While the outline is indicative of the thoroughness of the factors considered and their coordinated treatment, it should be noted that the considerations developed for that study were quite specific to the project, its location, and the available data.

Freeport Harbor. For the urban setting of the Freeport Harbor study, no change of habitat acreage was projected; instead, the environmental analysis was focused on estimating the loss of habitat value that would occur in dredged material disposal areas. The evaluation was conducted using the 1976 HEP procedures but modified so as to relate numerical ratings to a judgmental recognition of habitat quality and wildlife abundance (Table 33). Thus, although existing conditions were numerically evaluated and future conditions were qualitatively anticipated at target year intervals by having established a simple correspondence between numerically and qualitatively assessed conditions, the planners could evaluate impacts and calculate mitigation requirements.

Rowlett Creek and Walnut Williamson Creeks. Unlike any other of the case studies, both of these were expanded information flood plain studies and employed spatial analysis data management techniques to evaluate the implications of alternative future land use conditions on habitats and their

biota. Futures were projected based on information from local and regional planners and analyzed in terms of conditions reflecting the implementation of various flood plain regulatory policies. Physical parameters, such as land use and habitat, were assigned to grid cells to describe both existing and future conditions. Once the data bank was established, spatial analysis was simply a matter of computer manipulation of the data to determine habitat acreage losses and gains over time. A basic step to assessing impacts on biota in the Rowlett Creek study was the listing of species associated with the various habitats. Once the listings were developed and changes in habitat acreages projected, then changes in habitat quality and critical habitats were deduced. In the Walnut-Williamson Creek study, the habitat analysis was accomplished by interfacing HEP procedures with spatial analysis methodology. An example of the type of output obtained is shown on Figure 18. Appendix B exhibits further information on the methodology applied in the Walnut and Williamson Creeks Study. In this study, the measure of habitat quality value was discounted with decreasing distance from urban activities. The discount zones were:

a. greater than 400 feet from urban habitat, the zone of primary habitat. Values not discounted in this zone.

b. between 200 and 400 feet from urban habitat, the zone of transition impact. Amount of discount determined by professional judgment.

c. within 200 feet of urban habitat, the zone of immediate impact. Amount of discount determined by professional judgment.

Techniques Useful in Anticipating and Analyzing Changes in Land Use and Habitat Quality

In Planning Context, Utility of Techniques Incorporates Balance with Judgment and Informed Opinion

From the overview of the variety of methods presented in this chapter it is evident that there is no one best method or one that can be applied to the range of tasks to be accomplished in a planning study. However, it is noted that there are types of technical tools available which can be useful in accomplishing individual aspects of planning. The actual utility of a particular tool would be influenced by the circumstances of the study as well as by the level of information necessary to develop recommendations or make a decision. In this respect, environmental planning is analogous to statistical analysis since the selection of a technique is guided by the nature of the data and the inferences sought.

A tremendous volume of material has been written on both the philosophy and technique of impact assessment and environmental analysis. One effort which has focused on examining the literature and identifying techniques having field planning application is being conducted by the U.S. Army Engineer Waterways Experiment Station (WES). The work has produced an engineering circular summarizing 69 techniques and 28 general references having relevance to many aspects of environmental analysis (U.S. Army Corps of Engineers,

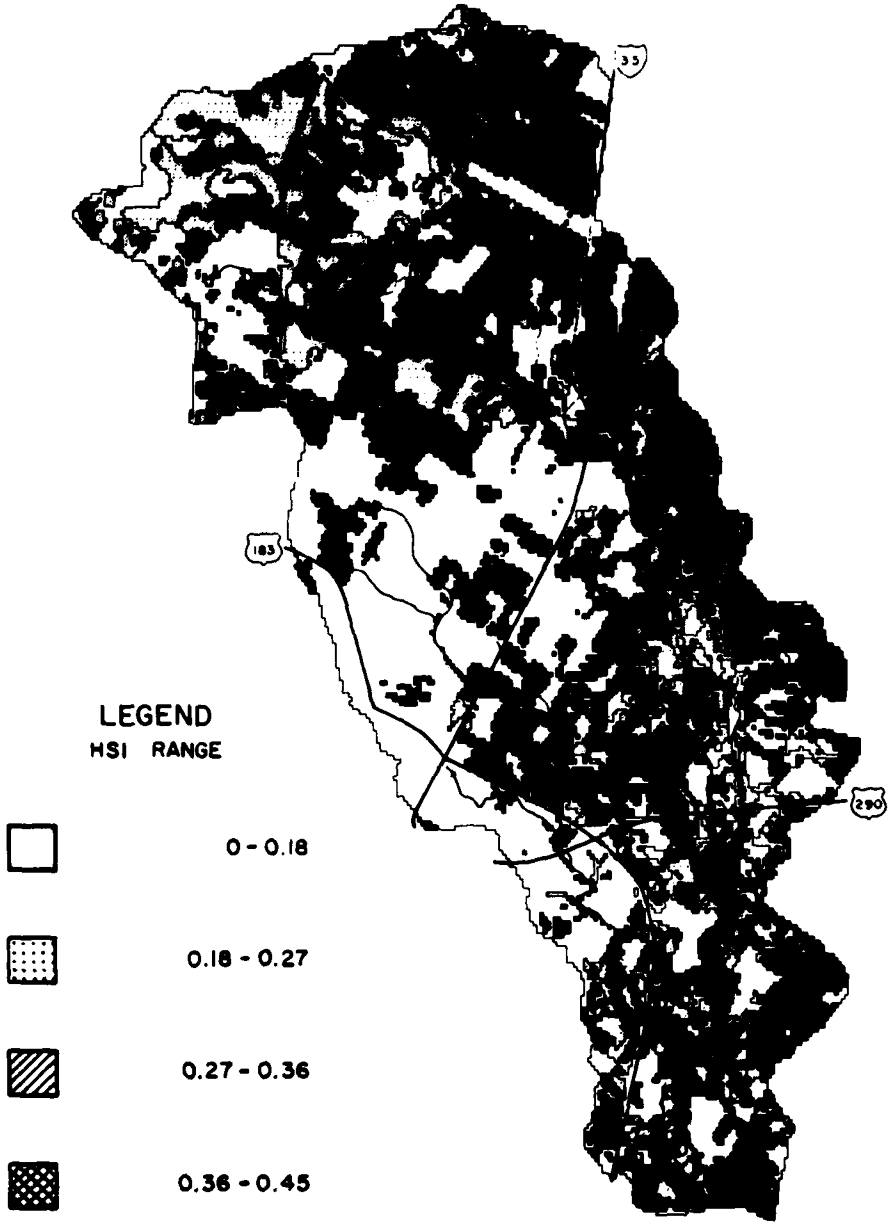

Figure 18. Example of type of output resulting from interface of spatial analysis methodology with the Habitat Evaluation Procedures on the Walnut-Williamson study, Fort Worth District. This figure displays the 1979 Habitat Suitability Index for red-tailed hawk, showing the quality of habitat for that species for the Walnut Creek Watershed. (From Webb, 1981)

1980). In that circular, references are classified by planning tasks and activities. Subsequent work has identified additional techniques and attempted to key them to planning steps in the 1980 P&S, management measures, planning actions (e.g., data collection and forecasting), form of output/display, and general type of technique (e.g. checklist, weighting-scaling, and forecasting). This work is mentioned here because it should provide guidance to that portion of the overwhelming amount of environmental analysis literature which has demonstrated a potential for use in planning.

Earlier, it was pointed out that there is a similarity between statistical analysis and environmental analysis with regard to the circumstances of technique selection, but that analogy ends with technique application. As evidenced by statistical packages, statistical techniques require particular inputs in particular format in order to process data in a sequence of established steps. In contrast, environmental analysis techniques must be fairly flexible in order to accommodate the study-specific differences of kinds of information, emphasis, and objectives. Because of the uncertainty and perception inherent to planning, the conduct of a planning study involves a considerable amount of judgment, informed opinion, and even imagination which by necessity also extends to how a technique is modified for application in the study. Planning, then, is not accomplished through a technique or even a sequence of techniques; the role of techniques in planning is to provide a tool for use in dealing with problems and needs. For this reason, it should be clear that reliance on techniques would not only paralyze the spirit of planning but would constrain the results. Thus, this report strives to make the point that any consideration of techniques, whether for their development, implementation, or guidance to usage, should be coupled with concern for:

a. The problems involved; this includes the underlying perceptions of land use change, environmental response to change, and the need and difficulties in measuring responses and planning for response (Chapter II).

b. Utility of the information a technique produces; in particular, how that information feeds into the recommendations and decisions that are made at the end of the planning process.

It is apparent that techniques can be better adapted and applied if the planning process is appreciated and the nature of the problems are recognized.

Types of Techniques

Although innumerable techniques have been developed for diverse analytical purposes such as habitat quality, agricultural potential, and impact assessment, specific types of tools can be identified. The types which appear to have relevance to tasks in forecasting wildlife futures include:

professional opinion
tabulations
overlay mapping
checklists

matrices
coincident tabulation
networks or impact trees
indices
transformation curves (for converting measured values to index values)
group consensus
weighting-scaling
spatial data management
spatial analysis
ecological unit analysis
capability analysis
models, either qualitative or quantitative
scenario development
trend analysis
cross impact analysis
locational attractiveness analysis
pattern recognition
statistical analytical techniques for significance determination or
  parameter interrelationships (including multivariate analysis,
  regression analysis, and other lesser used techniques*)

This listing does not include the companion processes that may be necessary to apply a given technique, e.g. the input of social involvement to scenario development or the historical inventories necessary for trend analysis. Also, the listing does not attempt to group techniques which have similar elements or which are typically applied to complement each other for a particular objective: for example, professional opinion and group consensus both have a large element of judgment, while locational attractiveness analysis usually is accompanied by spatial analysis and some level of regression analysis.

All of the techniques listed have been employed in some combination to some aspect of the documents which have been overviewed in this chapter. Several of the techniques are easily understood and nearly universally applied as aids in the planning process, e.g. tabulations and matrices; others are commonly applied but the implications or interpretation of their use may not always be realized, e.g. weighting-scaling techniques and indices. A techniques manual which would provide guidance to determining what techniques would be most appropriate and how to use them is an idealistic impossibility, not only because of the high-degree of study-specific variation but also because of the very nature of planning. Where guidance could be most helpful is in providing methods for making decisions as to what factors to include in a study or how to organize the overall thought process. The Environmental Quality Evaluation Procedures (Water Resources Council, 1980) is an example of

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*For example, in a discussion of methods appropriate for analyzing environmental data, Jameson (1976) briefly mentions the following: cluster analysis, ordination, discriminant function analysis, and canonical correlation analysis. However, Jameson did not clarify through example or reference how these techniques would be applied. The literature review for this report did not identify any case studies describing the application of these techniques for forecasting land uses or wildlife conditions.

such guidance, particularly for environmental concerns. An excellent book that shows how to formulate, use, and apply a variety of methods to environmental problems has been written by John Sinden and Albert Worrell (1980).

Nevertheless, techniques guidance is needed and can be particularly helpful if it focuses on the attributes of a technique or the analytic purpose it is used in. In addition to Sinden and Worrell (1980) and the Corps study of environmental analysis techniques (U.S. Army Corps of Engineers, 1980), there are other useful publications which have reviewed, described, or compared techniques that are pertinent to various aspects of environmental planning. For example, Warner and Preston (1974) review overlay, checklist, matrix, and network methodologies, as well as a fifth category they call Ad Hoc (which is useful for identifying broad areas of possible impact).* Twyford and Baecher (1977) provide a good review of techniques for capability mapping as well as a thorough discussion of the advantages and disadvantages of scaling and weighting and the pitfalls of transforming such values.

Reviews and summaries of habitat evaluation methods are contained in a report by the U.S. Army Corps of Engineers, Institute for Water Resources (1980). Based on procedural characteristics, the methods assessed were categorized into four groups. Except for methods in Group IV, all include a procedure for conducting an inventory of key habitat components:

Group I: Methods evaluate habitat quality for a broad spectrum of species and typically consider a wide variety of land uses. Include a procedure for integrating habitat quality and habitat quantity into an acre-habitat value.

Group II: Methods do not relate habitat quality to any particular wildlife species or group of species.

Group III: Methods focus on the habitat of only a few, highly selected wildlife species.

Group IV: Methods incorporate a supply-demand analysis of wildlife habitat, identify attributes of wildlife habitat to be considered, and analyze habitat through the recognition of environmental conditions.

Table 34 is a matrix of the various methods; it summarizes them, by group, as to certain criteria which are descriptive of the circumstances under which each would be most suitable for use.

Finally, the U.S. Department of Agriculture, Forest Service (1980) provides a good overview and discussion of analytic procedures for assessing ecological production (wildlife and fish) and ecological quality (relative health of an ecosystem). In considering techniques for assessing ecological

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*As indicated earlier, techniques cannot be packaged for planning; such an idea could only be appealing to those who do not understand planning since it would stunt the process and insult the professional planner.

TABLE 34

Matrix to Summarize Habitat Evaluation Methods in Relation to Key Criteria (From U.S. Army Corps of Engineers Institute for Water Resources, 1980)

	METHODS BY GROUPS																			
	I							II						III					IV	
MATRIX CRITERIA	Hamor, 197.	Thomas et al., 1976.	Whitaker, McCuen; 1975, 1975.	U.S.D.A., S.C.S., 1977.	Nichols et al., 1977	U.S. Fish & Wildlife Service, 1980.	McClure et al., 1979	U.S. Army Corps of Engineers, LMVD, 1979.	Rumsey, 1979.	Herin, 1977.	Daniel and Lamaire, 1974.	Thomas, 1974. Applegate, (undated)	Golet, 1976. Larson, 1976.	Brabander and Barclay, 1977.	Graber and Graber, 1976.	Willis, 1975.	Whitaker et al., 1976.	Buckner and Perkins, 1976.	Lentz, 1973.	Cowan, 1972. Smith, 1974	Russell et al., 1980. Williams et al., 1978.
PRIMARY USE																				
baseline condition																				
assessment of alternatives																				
management																				
LAND USE CONSTRAINTS																				
no constraints																				
urbanized																				
agricultural																				
forest																				
water resources																				
mixed																				
open																				
ENVIRONMENTAL PARAMETERS																				
flora																				
fauna																				
human influence																				
habitat																				
land use interspersion																				
land use density/diversity																				
carrying capacity																				
PERSONNEL REQUIREMENTS																				
technical																				
professional																				

production, emphasis was placed on those that identify key habitat or population variables and that quantify the relationship between key variables and ecological production. In the Forest Service's overview, techniques were categorized by the way in which their output expressed ecological production: as species occurrence, as population quantities (numbers or biomass), or as population age and size structure. Table 35 summarizes the Forest Service study findings on the attributes of terrestrial analytical procedures.* As presented in the literature, an individual technique may have been developed for a particular species, area, or region and if it has predictive capabilities, it is generally spatial rather than temporal. Table 35 refers only to references that have been finalized even though the Forest Service (1980) did include a few sources that are in draft form.

In considering techniques for assessing ecological quality, the Forest Service (1980) reviewed diversity indices and what the report termed alternative methods. Thirty-two diversity indices were identified and evaluated against certain specific and general criteria to ascertain the suitability of each index for providing a meaningful measure of ecological quality by way of biotic diversity. The five diversity index procedures having the highest ratings are given on Table 36. Alternative methods for measuring ecological quality typically consider some combination of the following factors: vegetative patterns, land form features, species occurrence, relative abundance of mammals and birds, critical habitat, land use, and land productivity. The Forest Service review observes that "the total amount of ecologically valuable information available from application of some of the methods discussed might provide the basis for a relatively reliable estimate of the ecological quality of a given area." The Forest Service report (U.S. Department of Agriculture, Forest Service, 1980) review included seven methods that could be alternatives to diversity indices for measuring ecological quality. However, only five of the seven have been published; the applicability indicators for these five are given on Table 37.

Examples of Techniques Exhibiting Potential

The previous section briefly considered the range of types of techniques available and highlighted the contents of some reports that have reviewed techniques. Although a large number of references are cited in the previous section, the utility of the technique that a particular reference offers is neither easily determinable nor presentable. For example, a technique that has been developed to analyze a specific bear population in Montana might be significant if it is readily adjustable to another area or if the approach can be adapted to study another species; however discerning, distilling, and explaining the significant transferable elements of a technique in a way that a user can quickly pick up on it may be counterproductive. Similarly, a discussion of the advantages, disadvantages, when to use, how to use, etc. of matrices would clearly overcomplicate this extremely useful, flexible, and single tool. Nevertheless, there are certain references which, in the opinion of this study, describe techniques that are prominent in having, or possibly

*The study also included 34 techniques for aquatic analytical procedures.

Table 35

Summary of Attributes of Analytic Procedures Which Identify Key Habitat or Population Variables and that Quantify the Relationship Between Key Variables and Some Expression of Ecological Production
(After U.S. Forest Service, 1980)

		Type of Output from the Procedure (Means of Expressing Ecological Production)				Type of Input to the Procedure		
Procedure	Analytical Techniques Employed	Habitat Quality	Species Occurrence	Species Population	Species Structure	Wildlife-Habitat Relationship	Habitat Variables	Population Variables
Asherin, Short & Roelle (1979)	Multiple regression	x				x	x	
Boyce (1977)		x				x	x	
Brabander & Barclay (1977)	Multivariate analysis, Regression analysis	x					x	
Buckner & Perkins (1974)	Expert opinion	x				x	x	
Caswell (1972)	Differential equations			x				x
Comins & Blatt (1974)	Differential equations			x			x	x
Craighead, Varney, & Craighead (1974)	Simulation model, Regression analysis			x	x			x
Cromer (1978)	Simulation model			x	x			x
Crowe (1975)	Simulation model, Linear regression			x	x			x
Davis (1967)	Linear programming			x		x	x	x
Garcia, Schreuder, & Taber (1976)	Simulation model, Regression analysis		x	x	x	x	x	x
Gause (1934)	Alternative equation			x				x
Giles & Snyder (1970)	Composite function			x		x	x	x
Hawes & Hudson (1976)	Expert opinion	x				x	x	
Hoar (1980)	Simulation model	x				x	x	
Lentz (1973)	Expert opinion	x		x		x	x	
Leslie (1945)	Matrix algebra			x	x			x
Lines & Perry (1978)	Expert opinion, Regression analysis, Index	x		x		x	x	
Lotka (1924)	Alternative equations			x				x
Medin & Anderson (1979)	Simulation model, Regression analysis			x	x	x	x	x

(Continued)

(Table 35, Concluded)

Procedure	Analytical Techniques Employed	Type of Output from the Procedure (Means of Expressing Ecological Production): Habitat Quality	Species Occurrence	Species Population	Species Structure	Type of Input to the Procedure: Wildlife-Habitat Relationship	Habitat Variables	Population Variables
Pennycuick, Compton, Beckingham (1968)	Matrix algebra			x	x			x
Poole (1971)	Factor analyses, Matrix algebra			x				x
Powell (1979)	Alternative equations			x	x			x
Rykiel & Kuenzel (1971)	Differential equations			x				x
U.S. Army Eng. Div., LMVD (1980)	Transformation curves, Expert opinion	x					x	
Volterra (1926)	Alternative equation			x				x
Wallmo et al. (1977)	Index	x		x		x	x	
Whitaker, Roach & McCuen (1976)	Expert Opinion	x				x	x	
Williams et al. (1978)	Bayesian statistics, Pattern recognition theory	x	x	x		x	x	
Willis (1975)	Expert opinion	x	x	x		x	x	

Table 36

Applicability of Diversity Index Methods for Assessing Biotic Diversity
(After U.S. Forest Service, 1980)

Method	Formula	Rating (%)	Comments
Kempton, 1979 (Modified from Hill (1973))	$e_r(m) = \sum_{i=1}^{s} C(N_i, r) C(N_i, m-r)/C(N, m)$	77.8	Standardizes sample size, improve efficiency of which results in improved discrimination between communities
Levins, 1968 (ecological)	$H_j = \exp[-\sum_{i=1}^{m} pij \log_e pij]$	56.4	Provides a measure of range of occurrence, degree of specialization or generalization (niche breadth of a population), and an assessment of the interaction among species.
Pielou, 1966a (plant communities)	$\tilde{H}\ pop = \frac{1}{(z-t+1)} \sum_{k-t}^{z} h_k$	37.2	Provides a reliable estimate of the diversity per individual in the whole population
Pielou, 1966b (pattern)	$D = B(n)/E[B(n)]$	33.0	Value of the index is dependent on the investigator's choice of observational methods, however, is useful for comparisons among several communities and between earlier and later conditions in a given community when data collection methods are standardized.
Hill, 1973	$N_a = \{\sum_i P_i^a\}^{1/(-a)}$	33.0	Relatively simple and well-understood.

Note: $e_r(m)$ = expected number of species with abundance r in a subsample of size m

H_j = ecological diversity as a function of the number of foliage types or habitat zones occupied and the equitability of distribution within these types or zones

$\tilde{H}$ = an estimator of H pop which is the average population diversity in an indefinitely large sessile population, defined by Shannon's formula

D = ratio of the mean species composition of a group of n neighbors, obtained from a random sample of such groups, to the expected mean value

N_a = an estimate of the effective number of species in a sample, considerating the likelihood of including or excluding the rarer species

Table 37

Alternative Measures for Measuring Ecological Quality
(From U.S. Department of Agriculture, Forest Service, 1980)

Method	Data Commonly Available: yes	Data Commonly Available: no	Field Data Collection Difficult: yes	Field Data Collection Difficult: no	Data Computation Difficult: yes	Data Computation Difficult: no	Applicability: National	Applicability: Regional	Applicability: Local	Applicability: Species Only	Applicability: Habitat Only	Applicability: Species/Habitat	Ranked Suitability*
Ecological Index (Klopatek et al., 1980)	x			x		x	x	x	x			x	1
Illinois Natural Areas Inventory (White, 1978)	x			x	x			x	x		x		3
Spatz Similarity Index (Spatz, 1970)	x			x	x				x			x	4
Species Richness Species - Area Curves (e.g. Hopkins, 1955)	x			x		x		x	x			x	5
Spatial Diversity (Mead, 1980)	x			x		x		x	x		x		6

*Rankings based on the following rating criteria:

Number of different cover types	Species occurrence of mammals
Spatial distribution of cover types	Average abundance of mammals
Vegetational succession	Critical habitat
Species occurrence of birds	Land use
Average abundance of birds	Land productivity

Methods ranked as numbers 2 and 7 are not included here because they are in draft form and not yet finalized.

having, potential for use in anticipating land use or wildlife condition changes accompanying water resource development.

Among the techniques considered to be particularly useful for forecasting land use changes are:

a. The HEC-SAM (Spatial Analysis Methodology) System (U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1980).

b. The Total Resource Information (TRI System U.S. Dept. of Agriculture, Forest Service, 1978).

c. The Alternative Land Use Forecasting (ALUF) Program (Krouse and Goicoechea, 1981).

d. The various analysis techniques described in Chapter IV which incorporate an analytical integration of the natural and socio-economic environments, including: McHarg (1971), Wilkerson et al. (1972), Wuenscher and Starrett (1973), Nowland (1976), and Sargeant and Berke (1979).

e. The development of scenarios. There is not a single method for developing scenarios, but there is a large amount of literature on the subject. The U.S. Army Corps of Engineers Institute for Water Resources (1977) describes some particular techniques. Creighton (1976) gives a good discussion of the advantages and general process of scenarios development. Hirschhorn (1980) also provides a good basic discussion of approaches as well as a recent bibliography.

Both the HEC-SAM System and the TRI System are comprehensive spatial data management systems. While neither HEC-SAM nor TRI include specific techniques for projecting futures they are important because they provide a means for handling data for analysis. The ALUF Program does provide an analytical technique for deriving future land use patterns.

HEC-SAM System is actually a collection of gridded data base management and analysis computer programs that are capable of creating and maintaining spatial data files, retrieving and displaying file contents, and linking data sets to sophisticated computer models. With respect to environmental analysis, HEC-SAM can help in evaluating plan alternatives and projected conditions because it can quickly manipulate data to:

-Forecast changes in habitat units by wildlife species and the ecosystem,
-Catalog environmental habitat changes from changed land use, (coincident analysis)
-Forecast changes in land surface erosion and transport for land use and engineering works changes,
-Forecast changes in runoff quality from changed land use,
-Forecast changes in stream water quality.

-Develop first order attractiveness and impact spatial displays,
-Identify enriched habitat zones by ecotone analysis.

Both the Rowlett Creek and Walnut-Williamson Creek floodplain information studies produced by the Fort Worth District (and overviewed in this Chapter and in Appendix A) document the application of this method.

While HEC-SAM operates on a gridded data base, the TRI System manages data delineated by compartments, whose boundaries are given by land features identifiable on the ground, aerial photographs, and topographic maps. TRI provides storage and retrieval for all in-place resource data. The data is indexed in 14 map layers which correspond to the type of resource data file (Figure 19). The Forest Service uses TRI to compile data on vegetation management accomplishment (timber harvest, slash treatment, reforestation, range revegetation, etc.) and to develop timber management plans. It would seem that TRI could be applied in water resources planning to group data by ecological units. According to Jameson (1976) this type of a data bank may be more economical with respect to time and funding than gridded data banks. The Chicago District is using the TRI approach in its current planning study of Little Calumet River, a flood control and recreational navigation project near Gary, Indiana (Personal Communication, June 1980, Ed Hanses, Chief, Environmental and Social Analysis Branch, Chicago District, U.S. Army Corps of Engineers, Chicago, Illinois).

The land use forecasting model developed by the U.S. Army Corps of Engineers Institute for Water Resources (Krouse and Goicoechea, 1981) uses grid cell data to develop future land use patterns. In this model ALUF is the main program which accomplishes the actual allocation of future land use to specific grid cells. A secondary program, ELUA (for Existing Land Use Analysis) is used to help identify significant land use location factors for the ALUF allocation process. The ELUA identification process is based on the relationship between land use locations and other data available in the grid cell data bank. ALUF incorporates both attractiveness and distance determination factors; the kinds of data commonly used for allocating future land use in this model are:

a. Access (distance) - transportation, central business districts or regional centers, dependent activities.

b. Proximity to compatible land uses

c. Physical land attributes (developability) - slope, drainage, type of cover, soils

d. Infrastructure - sewers, water, gas, power, mass transit

e. Zoning

f. Ownership

g. Land prices

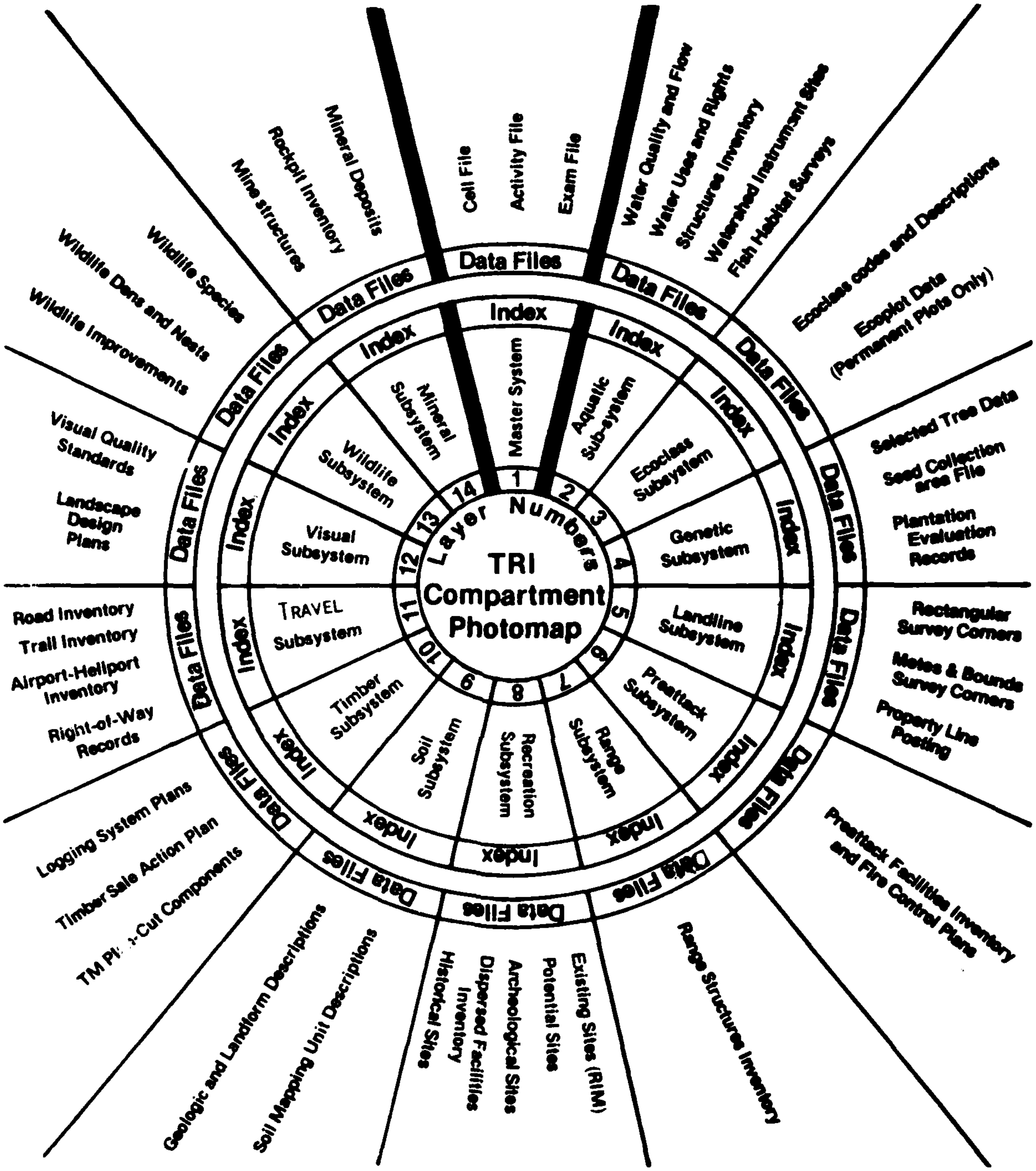

Figure 19. TRI System data base map showing the 14 index layers and their associated data files. (From U.S. Department of Agriculture, 1978)

The survey of Corps field offices and review of Corps planning study reports clearly showed that the development of alternative future scenarios is a significant tool in the development of the most probable future. The utility of scenarios is well stated by Hirschhorn (1980):

> "Clearly, their predictive value is not relevant...Scenario writing can help people clarify goals by providing them with broad theories, concepts, and interaction of their organization and their context. Scenarios should consequently reduce people's commitments to a priori conceptions, theories, or goals, and break stereotypes and stereotypical thinking. Once people have widened their sights in this way they can then more carefully specify a theory of their context and more authentically clarify their goals."

He also points out that scenarios must be plausible or people will not take them seriously; that a good scenario optimally combines surprise and plausibility.

Among techniques considered to have particular potential for use in forecasting wildlife conditions are:

a. The METLAND Wildlife Productivity Assessment Procedure (Fabos, Greene, and Joyner, 1978) - described earlier in this chapter.

b. The regional evaluation rapid assessment methodology for habitat quality developed by Asherin, Short, and Roelle (1979) - described earlier in this chapter.

c. Certain techniques classed as Group IV in the U.S. Army Corps of Engineers (1980) review of habitat evaluation methodologies. The most developed of this group are Cowan (1972) and Williams et al. (1978) and are described in the following paragraphs.

d. The MAGI Geographic Information System (Maryland Department of State Planning, 1979); Antenucci, Miller, and Brunori, 1979) - described in the following paragraphs.

e. Computer-assisted resource management techniques developed for three projects in Georgia (U.S. Army Corps of Engineers, Savannah District, 1980) - described in the following paragraphs.

Both Cowan (1972) and Williams et al. (1978) employ an element of probability which would seem to be suitable for anticipating futures although neither technique actually projects futures. These techniques are summarized in Tables 38 and 39. Data and analysis for both of these procedures could be handled through a gridded data bank. The Cowan technique is simple, logical, and quantitative, yet undeveloped beyond its fairly primitive first attempt to anticipate the ecological impact on existing conditions of the Corp's proposed Platte River Dam in Nebraska (Personal Communication, July 1980, Dr. C. Michael Cowan, President, AESCO consulting firm, Lincoln, Nebraska). It would seem that the technique or a refined version of it could also be applied to a described set of future conditions.

Table 38

Key Elements of the Cowan (1972) Technique for Anticipating the Ecological Impact of a Proposed Impoundment
(From U.S. Army Engineer, Institute for Water Resources, 1980)

Synopsis:

This procedure is based on a supply-demand analysis which presumes a reciprocal relationship between the supply of an environmental resource and the value of that resource to wildlife. This procedure is designed to evaluate habitat for deer, birds, and fish. Resource supply (i.e., habitat required for each species) is determined from maps, and is categorized with respect to the needs of individual species. Resource demand is derived from information concerning population densities in each category of resource supply, and the maximum population a particular section of land can support. In this approach, the demand that each species exerts for each category of supply is defined as the percentage of the total carrying capacity that each category of supply is known to support. The impact of land use changes on habitat is determined by comparing supply-demand relationships in existing habitats and in projected habitats (after land use changes occur).

Key Inputs:

- maps (topographic and soils)
- field surveys (assessing water quality, physical parameters, flora and fauna)
- documented data (on wildlife, land use, and recreation)

Key Outputs:

- tables (illustrating environmental values based on probability of occurrence, and supply and demand of each habitat category)
- figures (illustrating resource analysis)
- computer printout sheets (field survey data)

Specified Key Assumption:

- no habitat evaluation assumptions specified

Table 39

Key Elements of the Williams et al. (1978) Technique for Analyzing Wildlife Habitat and Evaluating Alternative Wildlife Management Actions
(From U.S. Army Corps of Engineers, Institute for Water Resources, 1980)

Synopsis:

This procedure is based on Bayesian statistics, and provides a systematic analysis of habitat through the recognition of patterns of environmental conditions associated with specified (high or low) population densities of a particular wildlife species. Application of this procedure gives a measure of habitat quality which is expressed as the probability that an area sustains a high or low population density of a particular wildlife species, and, in addition, gives an estimate of the potential population density for the species within that area. The frequencies with which particular environmental conditions are associated with either high or low population densities are measured or estimated to develop conditional probability values. These values constitute habitat quality standards for opposing resource bases, where one resource base supports a high population density and the other supports a low population density. Intermediate environmental conditions that occur between the opposing bases provide criteria for estimating population levels for the area.

Key Inputs:

- questionnaire (concerning local environmental conditions)
- potential density calculation form
- interactive computer program (evaluating environmental conditions and identifying management strategies)
- field observations (of environmental parameters associated with population densities)

Key Outputs:

- evaluation of habitat suitability (probability that a habitat has needed resources)
- potential density estimates
- management priorities
- standardization of habitat conditions for comparison

Specified Key Assumptions:

- real and predictable relationships exist between sets of environmental conditions and the response of animal populations
- Bayesian statistical procedures are valid for estimating population densities

The infinitely more sophisticated procedure developed by Williams et al. is described as being orderly, consistent, and capable of generating information pertinent for making decisions on locating resource development (in this case oil shale production) so as to be compatible with sustained wildlife yields. This technique deals with the probability of a species occurring in an area given the existing cover type configuration or pattern. Thus, if future cover types were to be described, the technique could be applied to project the future probability of species occurrence.

The MAGI System has a software package capable of manipulating gridded data at any size and scale. The system has been used to analyze the location and potential of natural resources, and the pattern and extent of existing urban development and planned facility services areas and to evaluate alternative growth allocation consumption of the existing resource base. In agricultural studies, MAGI has been applied to evaluate agricultural potential and the probable vulnerability of undeveloped productive soils for transforming to future urban uses. Also, as part of a wild turkey restocking program, MAGI was employed in order to determine levels of potential wild turkey habitation based on criteria for location of existing turkey populations, turkey habitat requirements, and constraints due to human activities. While MAGI does offer a useful tool, it is clear that its utility lies in data storage and retrieval and computerized map display techniques rather than in a national method for automatically deriving future wildlife conditions from a data set. The MAGI capabilities and data base are continually being expanded; the 1980 version contained a wide variety of physical and cultural variables such as soil, slope, vegetative cover, historical and existing land use, edge effect, stream classification, and archeological sites.

The Savannah District's computer-assisted resource management techniques (U.S. Army Corps of Engineers, Savannah District, 1980) are the only example of computerized suitability analysis in a Corps office that this survey uncovered. The objective was to determine the suitability (most environmentally compatible and best use) of "land acquired for project operations and allocated for use as developed public use areas for intensive and recreational activities by the visiting public, including areas for concessions and quasi-public development."

Basically, the effort consisted of first compiling a computerized inventory of resource data variables (e.g., slope, vegetative cover, land use, and transportation and utilization) at three projects: West Point Lake, Lake Russell, and Clark Hill Lake. Once the data base was compiled and stored in grid cells representing 4.889 acres, it was analyzed to determine what sites would be most suitable for various recreational activities. The suitability analysis was based on definitions of criteria relating site characteristics to type of recreations. For example, sites having potential for intensive recreation would exhibit the following characteristics: non-developed, low erosion potential, capable of supporting septic tanks, adequate depth to bedrock, adequate depth to water table, flat to moderate slope, and suitability for beaches or boatramps. A search routine would then be needed to determine the location of cells suited for intensive recreation. The process would be repeated to produce various scenarios for each recreational activity.

District personnel were enthusiastic about the data base analysis technique and its efficiency in quickly evaluating an entire study area for a range of activities and providing them with information useful for narrowing the number of possible scenarios for land use and recreation down to the most desirable and logical plans (Personal Communication, April 1980, Jim Hardee, Recreational Planning Branch, and Micky Fountain, Environmental Analysis Branch, Planning Division, Savannah District, CE, Savannah, Georgia). Although the data base was analyzed for recreation, the district personnel believed it could be expanded and the technique applied to habitat assessment; this would probably require (a) adding variables to the data base as well as recalculating the existing base, and (b) defining the habitat criteria, i.e. what combination of resources would be best suited for what species.

Considerations in Implementing a Technique

The material compiled for this overview indicates that that portion of the planning process concerned with projection of future land use and wildlife conditions is a process in itself. Thus, the projections are accomplished through the use of several techniques which may be applied sequentially or simultaneously, but which collectively yield the information for making the futures analysis. Obviously a myriad of techniques are available, and the planner employs the combination which he judges will be most useful to him. There are several aspects to technique utility, e.g.: adaptability (including locational and circumstantial), data availability, products, personnel needs, efficiency of time and money, and user preference for a familiar tool. In order to select an appropriate complement of techniques, there must certainly be some appreciation for these aspects. Additionally, consideration must be given to the context of the particular study problem and the nature of the decision that will need to be made to develop a recommendation for problem solution. Herson's (1977) suggestion that 'impact aggregation is a "hotly debated" issue because the procedure is considered in the abstract, without reference to a particular decision context' might well be true of the controversies that frequently surface as to the merits of other techniques, particularly habitat evaluation. The point is that futures projection is a process driven by planner's judgment and is not a recipe of techniques to follow. Planning then begins with determining the problems that need to be solved rather than the techniques that need to be applied.

Regardless of study specific circumstances there are certain elements which are held in common: data organization, data analysis, results interpretation, and results presentation. Further, despite study differences, there are certain techniques that are particularly useful in dealing with these elements: namely, spatial data management and spatial analysis. These are computerized techniques that greatly expand the capabilities for manipulating data including graphic display as well as computation. In addition to the spatial management and analysis based methodologies mentioned in the previous section, there are other references that would be particularly useful in implementing spatial techniques. These include: U.S. Army Corps of Engineers, Hydrologic Engineering Center (1978a, 1978b) and French et al. (1980).

To users of spatial data management techniques, the U.S. Army Corps of Engineers Hydrologic Engineering Center (1980) offers the following advice:

a. Know your problem/needs in detail prior to examining spatial data management systems, (i.e. don't let the study's problems be defined by the performance capabilities of a particular system).

b. Determine how you will solve your problems (or make applications) irrespective of the capabilities of the existing system). (This enables efficient use of money and manpower resources).

c. Be aware that there are very great differences between automated drafting, spatial data systems, and data used primarily for mapping and statistics, and spatial data systems and data that are usable for engineering type applications.

d. Thoroughly investigate features and capabilities of alternative systems, (i.e, a system that is right for someone's needs may not be relevant to another's).

e. Do not expect magic, (i.e. expect that difficulties will occur and be flexible).

f. Willingly commit the personnel resources to make the system your own.

g. Continuously ask questions of the developers/services, probe the limits of capabilities, and presume a normal feature of sophisticated complex systems is that they should be continually adapted and augmented over time.

Whatever techniques are employed to aid in forecasting futures, their implementation within environmental assessment and planning would be improved by taking into account the following considerations, posed as guiding principles by Wuenscher and Starret (1973):

a. Logical ecosystem units should be used as planning units to the greatest extent possible (e.g. watersheds, vegetation types, or some combination of biotic and physiographic characteristics as for tidal marshes or dunes).

b. Important natural processes* should be identified as they occur in ecosystems of several sizes ranging from the whole region to individual small watersheds or other local ecosystem units. The

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*For example, water quantity and quality related processes that would be of concern include use of water by vegetation, runoff regulation by soil percolation, aquifer discharge to maintain stream flow during dry periods, soil stabilization be vegetation to prevent stream siltation, filtration of urban runoff by vegetation, etc.

project alternatives should be considered in relation to their impact on these processes in each local ecosystem unit(e.g. small watershed) and their relevance to regional units (e.g. river basin).

c. The specific land areas of biotic communities most important to the continued operation of these processes should be identified and located on the ground (e.g. floodplains, riparian plant communities, and vegetation and soils of steep slopes).

Wuenscher and Starret indicate that application of these principles enables the development of plans that take advantage of environmental goals and opportunities and so protect lands necessary for the important natural processes. In environmental planning, the utility of a technique is not judged by whether or not it is the best or most accurate, but whether or not it has an appropriate or significant role in developing plans that successfully minimize impacts and promote environmental consonance. In general, if realistic assumptions are applied in use of a technique, then realistic results will be obtained.

Finally, in considering techniques for use in environmental assessment in water resource development planning studies, it must be remembered that the technique(s) selected to assess existing conditions must be compatible for use in assessing the types of data that will be descriptive of future conditions (Water Resources Council, 1980 a and b). This is so that different conditions can be better compared and their differences more clearly determined.

CHAPTER VII

RECOMMENDATIONS FOR ASSESSING

FUTURE HABITAT CONDITIONS FOR WILDLIFE

Faced with the task of forecasting with and without project conditions for wildlife, the environmental planner can generally obtain information from three data sources: historical conditions, existing conditions, and projected land uses. Any procedural tools that have potential for being effective in aiding the accomplishment of the task recognize not only that data availability and utility can vary considerably, but also that the ultimate objective is to anticipate the probable rather than to forecast the actual. These bounds were the development criteria for the recommendations presented in this chapter. In addition to these bounds, the recommendations also take the work unit findings into consideration and were prepared with the expectation that they would be applicable to planning studies of any size in any region.

The recommendations are presented in a way which is thought to be most useful to planners--as descriptions of strategies. Two such strategies or sets of recommendations are described here:

- a. What to do when using a habitat evaluation procedure which expresses habitat value as the numerical product of habitat quality and quantity.*

- b. What to do when using a habitat evaluation procedure which expresses habitat value based on land use characteristics.

These strategies provide two alternative frameworks that should be suitable to most, if not all, of the planning study approaches taken in forecasting environmental conditions. It is important to note that these strategies merely describe frameworks and as such would provide only a superficial habitat assessment; because of study-specific differences and needs it is impossible to develop procedurally detailed recommendations. It is within the responsibility and the capability of the environmental planning team to compile the kind and depth of predictions needed as input for the assessment and to take care to produce a habitat evaluation at a level of detail appropriate to the investigation.

Regardless of the details of any particular planning study, it is emphasized that effort to forecast and evaluate habitat conditions should be conducted in three parts:

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*This type of habitat evaluation procedure is commonly employed in planning studies and encompasses most (U.S. Army Engineer Institute for Water Resources, 1980) of the existing habitat evaluation methodologies including both the popularly applied HEP, developed by the U.S. Fish and Wildlife Service, and HES, developed by the Corps Lower Mississippi Valley Division.

a. Evaluation of existing habitat and prediction of probable land use changes by professional with credentials.

b. Interpretation and conversion of predicted probable land uses into expressions that are meaningful in terms of habitat composition.

c. Evaluation and final forecast of probable habitat by persons having credentials in biology, ecology, and wildlife management.

The two strategies described in this chapter are similar in requiring information on existing habitat conditions and projections of the types of distribution of future land uses, and in being compatible with grid cell-based data management techniques. Both strategies are specifically for use in planning and are accomplished through the same three phases: evaluate existing habitat and project land uses, interpret projected land uses in terms of habitat, and evaluate future habitat. Also, both strategies can be applied to whatever group of wildlife is of interest, for example, a single species, a group of species, or a guild. The major difference between the two is in the treatment of habitat value: the first treats it in terms of a quality index by vegetative cover type and the second in terms of relationships between land types and habitat conditions.

Before proceeding with the descriptions, it should be noted that in this chapter, the term land use refers to the entire range of use and nonuse of land from urban/industrial center to wilderness area. The intention is to encourage a broader perception of habitat, to consider it as existing (at least theoretically) across the entire use-nonuse range. This also enables the recommendations presented here to be applied consistently under any circumstances of surface expression.

When Using a Procedure Which Expresses Habitat Value as the Numerical Product of Habitat Quality and Quantity

Underlying Rationale for Development of These Recommendations

Basically, the essence of the various habitat evaluation techniques that fall in this category of procedures can be expressed as:

$$\boxed{\text{Habitat Value}} = \boxed{\text{Habitat Quality}} \times \boxed{\text{Habitat Quantity}}$$

The major difficulty in applying any such procedures for assessing future conditions lies in projecting the habitat quality under those conditions. By comparison, the means for estimating the other component, the future habitat quantity are easier, at least conceptually, because they are more apparent and more easily traced. Certainly the process for land use forecasting is heavily imbued with subjectivity and the vagaries of land ownership, yet projections of what acreage changes are reasonable to anticipate can be obtained. While

each of the habitat evaluation procedures in this category does describe a methodology for evaluating habitat quality under existing conditions, and while some acknowledge that there are studies in which future conditions need to be evaluated,* there is none that describes a procedure for how to go about forecasting habitat quality. For example, even what is widely considered to be the best developed of these procedures (the USFWS Habitat Evaluation Procedures) gives little indication of what items should be considered in projecting habitat quality values or how they should be considered:

> "Predicting future HSI. The same models that were used to determine baseline HSI values must be used to determine future HSI values. If, for example, a mathematical model was used to calculate baseline HSI, a related word model cannot be used to predict future HSI values, or vice versa.
>
> Estimating HSI values for future years requires predictions of changes in the physical, vegetative, and chemical variables of each cover type. Impact segment overlays can be used as an aid in estimating these variables. For example, seasonal flooding could alter a forest understory but not the canopy closure. Changes in interspersion relationships due to creation of new cover types or conversion of existing cover types also can affect HSI model output and can be easily measured on future cover type maps (impact segment overlays)." (Taken from ESM 102, section 5.2C; U.S. Fish and Wildlife Service, 1980)

Consequently, persons using such procedures to evaluate future conditions generally take either one of two approaches to predict habitat quality values:

a. Assume that the habitat quality index values calculated under existing conditions will be the same as those that would occur under future conditions. Thus, if in the existing conditions of the study area, the habitat quality index for white-tailed deer has a value of 0.8 in evergreen forest and 0.4 in deciduous forest habitat, then it is assumed that under future conditions, the index value for deer in evergreen forest would be 0.8 and in deciduous forest would be 0.4.

b. Based on professional judgment, assume adjustments to the habitat quality index values obtained for existing conditions in order to predict index values for future conditions. Thus, using the above example, the 0.8 existing condition index value for white-tailed deer in evergreen forest may be decreased to 0.3 while the 0.4 value in deciduous forest may be reduced to 0.2.

By either approach of assumption, the future habitat value will likely be different than the existing value because one or both of the components of the equation will have changed. In the first instance, the existing habitat

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*This is acknowledged primarily by indicating that the methods used in existing conditions are also to be applied to evaluate future conditions.

quality is retained so that the habitat value changes due to a projected change in habitat quantity. In the second, a change in habitat value is the result of a change in both habitat quantity and quality. When the professional judgment approach is taken, the adjustments to habitat quality indices are not arbitrary since they do reflect an educated opinion; however, because the elements that go into making the adjustment are usually vaguely indicated, if at all, it is probable that very often the judgment is quite subjective. Sometimes the user of the professional judgment approach will develop an innovative technique for adjusting habitat quality values so as to reduce subjectivity and to be able to construct a documentation of the rationale involved.

The work unit found two districts, Louisville and Fort Worth, that developed a methodology on which to base professional judgment for altering habitat quality indices. Descriptions of the Louisville District approach as employed in the Big Blue Lake and Louisville Lake Planning studies, and of the Fort Worth District approach, as used on the Walnut and Williamson Creeks expanded flood plain information study, are included in Chapter VI (section on "Studies Reported in Corps Documents") and in Appendices A and B. Although the procedures these two districts developed are quite different, both are practical and appear to be adaptable. In the Louisville District approach, habitat quality index values for areas that are expected to become disturbed are estimated through consideration of habitat analogy, disturbance frequency, and type of human activity. The Fort Worth District approach is based on zonal distance influence of human activity disturbance, or the distance-to impact of urban habitat on wildlife habitat.

Description of Strategy Recommendations

The set of recommendations given here is to some extent based on the approaches developed by the Louisville and Fort Worth Districts. They give particular attention to how human disturbance might be accounted for in habitat evaluation. Although it is a factor that can have considerable influence on habitat quality at the site of the disturbance as well as in the surrounding area, it is generally not given systematic treatment in the existing habitat evaluation methodologies. In reality, most of the circumstances in which this category of habitat evaluation procedures has been applied have not involved any significant level of human disturbance. However, it seems likely that the typical practice of evaluating the habitat of relatively empty and wild areas could become less usual since the types of water resource planning studies to be conducted will probably realize an increasing proportion of those in settings with development pressures. The habitat possibilities of such areas should not be routinely dismissed. It will also be noted that this set of recommendations does not give specific attention to other major habitat quality factors such as interspersion, vegetation attributes, water level fluctuations, and the ecologic value of linear features such as fencerow and riparian habitats; this is because the various habitat evaluation techniques usually accommodate such factors. For example, the Louisville District's approach to water level fluctuations and linear habitats (Table 32 and Appendix B) may be adapted to a planning study in which these features are important but are not satisfactorily addressed in the particular habitat evaluation methodology being employed.

The set of recommendations is described in the following paragraphs in terms of a three-phased strategy: evaluate existing habitat conditions, interpret projected land uses, and evaluate future habitat conditions. For simplicity, the description is concerned with only two time periods, existing and a future target year. However, any number of target years could be considered as long as a land use projection has been developed for each. Also, the description assumes that a variety of cover types would be analyzed for their value for each wildlife group of interest. However, depending on study design, the habitat value for any combination of wildlife could be assessed from any combination of cover types. Abbreviations used in this description are listed and defined in Table 40. Figures 20 to 22 depict the strategy.

a. Phase I: Evaluate Existing Habitat Conditions

A schematic of this phase of the strategy is given in Figure 20. Basically, habitat quality index values are determined for the wildlife groups of interest for the array of cover types that occur under existing conditions. To evaluate existing conditions, these values are adjusted to account for the human activity disturbance factor. This is done by reducing the index values by an amount that is estimated to be proportional to the extent that the disturbance detracts from the habitat quality.

Assuming that there is an association between human activities and land uses, the disturbances are related to land use type and distance from land use type. The amount of reduction is a matter of professional opinion and takes into account the possibility of a magnification of disturbance that may be the result of overlapping zones of impact from different land use types. Once the activity-adjusted index values are established, the habitat values are determined by multiplying them by the appropriate habitat quantities. Further calculations in order to determine habitat quality by wildlife group, cover type, or overall study area etc., depend on the study needs and the habitat evaluation technique being used.

b. Phase II: Interpret Projected Land Uses

A schematic of this phase of the strategy is given in Figure 21. Projected land uses are examined to determine which areas could provide habitat. Then, the cover types of those areas are identified. Habitat quality index values are assigned to the areas by determining which of the existing conditions cover types each area is most like and then applying that HQIV to the area. Assigning index values in this manner is crude; however, since specific habitat changes are poorly foreseen and occur subtly over the succession process, it is believed that this similar cover type approach is compatible with the level of information discernable on future conditions.

The assigned HQIV's are then adjusted to account for human activity disturbances in a way similar to adjustments made in Phase I for existing conditions, i.e., by considering what zones of land use activity impact the area and by reducing the HQIV by an amount proportional to the detraction to habitat quality for the wildlife group (Figure 22).

Table 40

Abbreviations Used in Description of Recommendations: Figures 20 to 22

Abbreviation	Meaning
HQIV	Habitat Quality Index Value.
HQIV-CT	Habitat Quality Index Value for a particular cover type.
HQIV-CT,E	Habitat Quality Index Value for a particular cover type under existing conditions.
HQIV-CT,F	Habitat Quality Index Value for a particular cover type under future conditions.
THQIV	Temporary Habitat Quality Index Value; assigned temporarily until amount of adjustment to account for land use-related disturbance is estimated.
AHQIV	Adjusted Habitat Quality Index Value; the temporarily-assigned value adjusted to account for the estimated amount of disturbance.

NOTE: The abbreviations in this section are used only to simplify the presentation and not to introduce a new body of acronyms or to displace existing ones.

- Determine which areas are known to have or would be expected to have any habitat value for the wildlife group of interest (i.e., individual species, guild, community, etc.)

- For each wildlife group in turn --

determine habitat quality index values for each cover type under existing conditions (HQIV-CT,E) by applying the method specified in the particular habitat evaluation method being used.*

determine which areas are known to have or are assumed to have their habitat quality affected by land use-related human activities.

Cover Types in Activity-Affected Areas	Cover Types in Areas Not Affected by Activities
Adjust (HQIV-CT,E) to account for influence of disturbance on habitat quality. This new value becomes the activity-adjusted habitat quality index value, or the (AHQIV-CT,E). A suggested framework for rationale for deciding amount of adjustment is given on Figure 22.	Retain the (HQIV-CT,E); this value then becomes the activity-adjusted habitat quality index value. (HQIV-CT,E)=(AHQIV-CT,E).

- Store the (HQIV-CT,E) of each area for use in Phase II.

- Determine existing habitat value by multiplying habitat quantity times (AHQIV-CT,E)

*If the HEP is the methodology being used, the (HQIV-CT,E) is no different from an HSI; if HES is being used, then it is the same as an HQI.

Figure 20. Components of Phase I: Evaluate Existing Habitat Condition.

- Determine which areas would be expected to have any habitat value for the wildlife group of interest

- For each area, determine the cover type; i.e., which of the existing condition cover types it is or is more like

- For each wildlife group in turn--

Assign a temporary habitat quality index value to each cover type under future conditions (THQIV-CT,F)

If an area's cover type is unchanged from that under existing conditions, then the (HQIV-CT,E) of that area becomes the (THQIV-CT,F) for that area.

If an area's cover type is changed (e.g., succession) from that under existing conditions, then the average of the (HQIV-CT,E) values of the cover type to which the area has changed to becomes the (THQIV-CT,F) for that area.

Determine which areas would be likely to have their habitat quality index values affected by land-use related human activities.

Activity-Affected Areas

Adjust (THQIV-CT,F)to account for influence of disturbance on habitat quality as expected under future conditions. This new value becomes the activity-adjusted habitat quality index value, or the (AHQIV-CT,F). A suggested framework for rationale for deciding amount of adjustment is given on Figure 22.

Areas Not Affected by Activities

Retain the (THQIV-CT,F); this value then becomes the activity-adjusted habitat quality index value.
(AHQIV-CT,F) = (THQIV-CT,F)

Figure 21. Components of Phase II: Interpret Projected Land Uses.

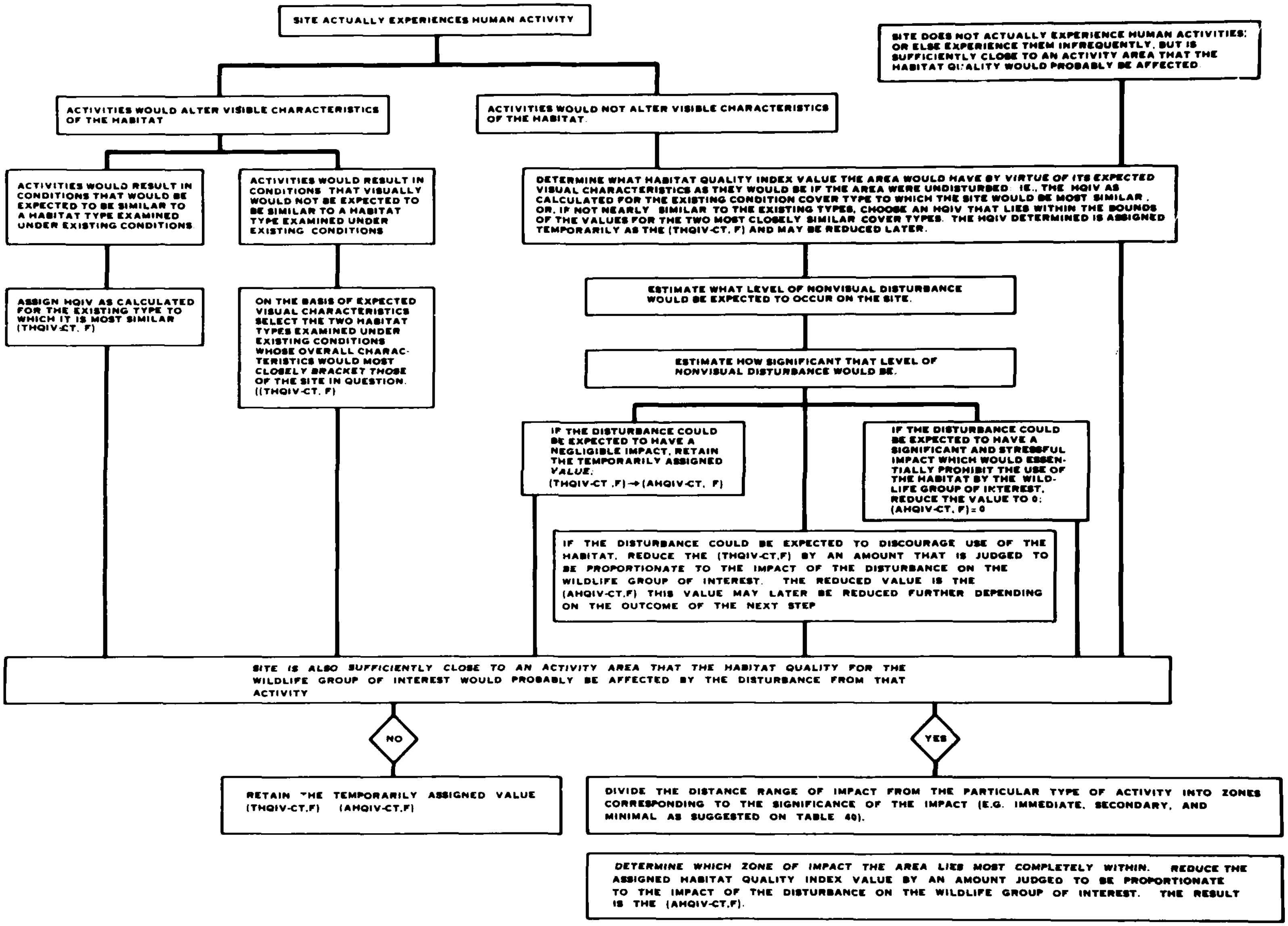

Figure 22. A suggested framework for rationale for judging the amount of adjustment to habitat quality index values in order to account for land use-related human activity disturbance.

Table 41

<u>Example of Distance Range of Impacts of Land Use - Related Activities on the Quality of Habitat of Wildlife Groups in A Hypothetical Study Area</u>

Wildlife Group	Land Use Types and Impact Zones* of Land Use - Related Activities												
	Industrial			Residential			Low Density Recreation			Pasture			..etc...
	I	S	M	I	S	M	I	S	M	I	S	M	
White-tailed Deer	on-site & up to .5mi	.5-1.5 mi	1.5-2.5 mi	on-site & up to .1mi	.1-.8 mi	.8-1.5 mi	-	on-site & up to .1mi	.1-.3 mi	-	on-site	-	
Carolina Wren	on-site	.05-1.07 mi	.07-.1mi	-	-	on-site	-	-	-	-	-	-	
Fox Squirrel	on-site	up to .2 miles	up to .4 miles	-	on-site	up to .1mi	-	on site	-	-	-	-	
Racoon	on-site	up to .5 miles	.5 to .7 miles	-	on site & up to .07 miles	.07 to .2 miles	-	on site & up to .05 miles	.05 to .07 miles	-	-	-	
. . etc. . .													

Note: Distance range of impact is estimated by conceptually superimposing a tract of each land use in the middle of an area which provides optimal habitat for the wildlife group.

*Impact zones suggested by the table are:

I - Zone of Immediate Impact; impacts are significant and stressful to the extent that the species avoids the area.

S - Zone of Secondary Impact; impacts are tolerated, they are significant to the species to the extent that they detract from the habitat quality

M - Zone of Minimal Impact; impacts are negligible, detraction from habitat quality is nearly imperceptible.

c. Phase III: Evaluate Future Land Uses

In Phase III, the habitat values under future conditions are calculated. This is done, for each wildlife group in turn, by multiplying habitat quantity times the quality index value yielded in Phase II (i.e., the (AHQIV-CT,F) shown on Figure 21). The evaluation is then completed by comparing habitat values obtained under existing conditions or any other target year as needed.

Assessment of Capabilities of the Strategy Recommendations

As may be evident from the dichotomous appearance of Figures 20 and 21, the strategy is structured so as to lend itself easily to computer-assisted sorting and analysis of the data. It has already been successfully demonstrated (e.g., the Walnut and Williams Creeks expanded flood plain study, Fort Worth District), that such data, which would largely be field parameters and habitat quality index values, is effectively and efficiently handled in a computer data bank and by the spatial analysis methodology (U.S. Army Engineer District, Fort Worth, 1980).

It is believed that this strategy can provide a simple but practical framework to: (a) supplement current methods for assessing the quality of existing habitat conditions; and (b) to aid professional judgment in adjusting and selecting quality values to describe the habitat quality of a projected land use. Thus, the recommendations suggest what and how to consider the influence of land use-related human activity disturbance on habitat quality; they do not provide formulas for a "more accurate" calculation of values.

It is emphasized that this strategy set of recommendations is not a procedure, but is instead a framework to be applied in conjunction with a procedure. For this reason, the strategy does not include recommendations for accomplishing several necessary tasks; these tasks include those which are either taken care of in the prescription of the habitat evaluation methodology being used or involve decisions that must be based on professional experience and judgment. Thus, this strategy does not include recommendations for deciding:

a. What wildlife group(s) to evaluate;

b. What cover types to select or how to delineate them;

c. What areas have and do not have habitat value for the selected wildlife groups;

d. Assumptions as to how to determine whether or not a particular level of activity disturbance is significant to the quality of habitat for the selected wildlife group(s);

e. The actual amount of reduction in quality to account for disturbance;

f. How to display habitat value, i.e., by cover types, by wildlife group(s), or for overall study area, etc.

Finally, although both the first and last phases of the strategy deal with the evaluation of habitat, it should be pointed out that there is no existing technique that truly evaluates habitat. The techniques involve procedures for deriving and assigning numbers to habitats, but they include no method for an evaluation of what the numbers really mean.

When Using a Procedure Which Expresses Habitat Value Based on Land Use Characteristics

The purpose of this strategy is to provide a means for interpreting probable future habitat conditions from projected land uses. Strategy development was oriented to take advantage of the analytical tool that spatial analysis of grid cell data offers. The following paragraphs present the rationale and assumptions that underlie this set of recommendations.

Development of Assumptions

During the conduct of the work unit, certain observations were made that became significant to the construction of this strategy. In particular, it was recognized that:

a. The classification name of a land use type conveys a level of information. For example, if an area is designated as low-density residential, then anyone can make some reasonable guesses as to some of the characteristics of that area. A person who is familiar with the general locality can make an even better estimate of the characteristics.

b. The distribution pattern of the various land use types in an area conveys further information.

Thus, if the land use type is known, a person knowledgeable of the locale can develop a description of that land parcel in terms of the following characteristics:

- The predominant cover type (e.g., vegetative or nonvegetative impervious, etc.)
- The predominant vegetative cover type (e.g., trees, shrubs, grass, and frequently even by dominant species),
- The vegetative strata, and
- The vegetative management practices that are employed.

If the land use pattern is also known, additional characteristics can be derived for each unit area of grid cell:

- The dominant edge type (e.g., vegetative/vegetative, or vegetative/nonvegetative; or perhaps a more detailed description);

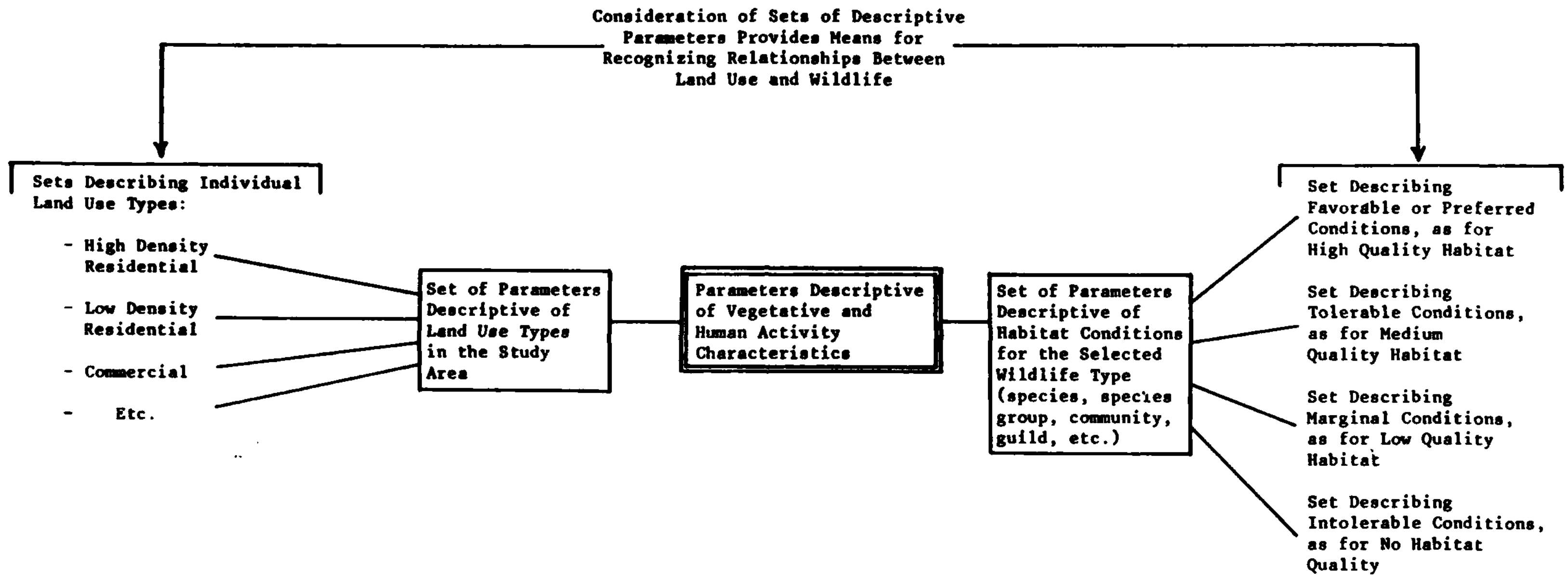

Figure 23. How parameters descriptive of vegetation and human activity characteristics can function as an interpretive linkage between land uses and habitat conditions.

- The relative proportion of each edge type;

- The number of separate contiguous areas of land uses;

- The number of different land use types;

- The presence of significant features such as fencerows, streams, and size of highway; and

- The characteristics of human activities.

A description of each unit area in these terms provides a characterization of many of the features that influence the quality of wildlife habitat. Conceivably, such a characterization could be done, at least on a gross level, without organized field effort through use of a land use map and familiarity of the area. This capability is central to the strategy since it is the concept that makes it workable. However, the role of field work in this strategy should not be underestimated since it serves to provide a sharper resolution of the details of those features that influence habitat quality in the study area and to observe what features may be land use related. Features that are characteristic of a given land use in the study area, or a portion of it, under existing conditions may well be indicative of a relationship between that land use (either throughout the area or that portion of it) and some component of habitat quality. If such relationships do exist, it is probable that they would also occur in that particular land use and area at a future time.

These observations lead to the development of the strategy's three basic assumptions:

a. First, that there are parameters which are descriptive of land use characteristics and which are also indicative of wildlife habitat.

b. Second, that some of these parameters can be directly obtained from a land use map while others can be inferred from that map if there is information from the locality as to the associations between certain parameters and land use types.

c. Third, that if relationships between land use types and any of these parameters are observed to occur under existing conditions, they will also occur under future conditions.

Acceptance of these assumptions makes it possible to assess habitat conditions by way of information on land use characteristics. More precisely, if such information is expressed as parameters descriptive of vegetative and human activity characteristics, it can function as an interpretive link between land use types and habitat conditions (Figure 23).

The significance of accepting these assumptions lies in their application to the planning activities concerned with describing environmental futures and anticipating project impacts. They enable the planner to make the most use of the available sources of information: (a) existing conditions which can yield

knowledge of the nature of the locality's relationships among parameters; and (b) projected economic and social conditions which can yield knowledge of the probable future land use patterns.

Descriptive Parameters

Based on the foregoing observations and assumptions, it is possible to identify the habitat-indicative parameters that can reasonably be forecasted through an interpretation or abstraction of future land uses. These indicators can be considered in three groups, which consist of parameters to abstract characteristics of: (a) land cover types; (b) features considered to be significant; and (c) human activities (Table 42).

Land Cover. The first group of parameters, those indicative of land cover, refers to the nature of the surface expression. The major categories of areal land cover are:

a. Vegetated
   i. trees
   ii. shrubs
   iii. herbaceous

b. Nonvegetated, pervious
   i. bare earth
   ii. water

c. Nonvegetated, impervious
   i. natural (occurrence of this type is unusual; e.g., rock domes and lava fields)
   ii. man-made

As indicated by Table 42, the land usage of a given unit area could be described by the relative amount of coverage, age, and arrangement of its land cover types.

Significant Features. The second group, called significant features, refers to instances of land cover that are important to habitat but that do not extend over broad areas and that are often linear. This includes features that are associated with certain land use types but are generally not mapped, for example, fencerows. It also includes those that may occur at large (i.e., are not necessarily associated with land use types) and that are usually mapped, for example, streams and roads occur in dense urban as well as in very rural land uses.

Human Activity. Group three, the human activity characteristics, try to capture the disturbance factors that affect wildlife use of habitat. This group characterizes the pollutants, event frequency, and event intensity of the mobile and stationary activities that are associated with different land uses.

In essence, then, this strategy operates by describing each unit area or grid cell not by land use type, but by the characteristics (Table 42) that

Table 42

Habitat-Indicative Parameters That Can Reasonably be Forecasted Through an Interpretation of Future Land Cover

Land Use Characteristics	Descriptive Parameter*
Land Cover	Predominant cover type Secondary cover type Age, predominant cover type Interspersion within predominant cover type Interspersion between cover types Edge, quantity Edge, quality Vegetative strata within predominant cover type Vegetative strata within secondary cover type Vegetative management practices
Significant Features	Linear vegetative features Water Impervious surfaces Bare soil areas Prominent physical features
Human Activities	Pollutant characteristics Event frequency Event intensity of: mobile activities, linear features; stationary activities, predominant cover type; stationary activities, secondary cover type

*Examples of how these parameters might be specified are given in Appendix C.

define each unit area's land use. Then, as suggested by Figure 23, these characteristics and their spatial distribution are analyzed from a wildlife point of view; this is done by redefining the characteristics in terms of various levels of habitat preference for the wildlife of interest and applying spatial analysis techniques.

Description of Procedural Framework for Application of Strategy

The strategy includes three phases, which are the same as for the alternate strategy described earlier in this chapter: evaluate existing habitat conditions; interpret projected land uses; and evaluate future land uses. The objectives and activities of each as specific to this strategy are described in the following sections. Figure 24 highlights the main components of the strategy and their interaction. It will be noted from this description that the information developed during application of the strategy as well as the results of the strategy are not exactitudes: they are based on abstractions, generalizations, and perceived associations, and are relevant to a grosser level of detail than is generally considered in most current habitat evaluation methods when applied to existing conditions. However, it is believed that the framework described here is compatible with the context and overall objective of planning, as well as with the level of detail possible in considering intangible forecasted conditions. It will also be noted that this strategy could be applied to evaluate habitat conditions for any number of wildlife species or species groupings.

As shown in Figure 23, the use of descriptive parameters is this strategy's means for relating land use to wildlife. Through inference, the strategy could also be applied to develop estimates of wildlife populations that would be expected to occur with whatever land use condition is forecasted. For example, if wildlife population data is available or obtainable for existing conditions for the species of interest, it could be used to associate habitat preference levels with an expectable population size range. This association would then be used in the final phase for estimating the most probable wildlife abundance. The approach of establishing a relationship between known population data and calculated estimates of habitat quality values for existing conditions and the extrapolating a projected population from estimated future quality values is not new and is commonly applied in habitat evaluation methodologies.

Phase I: Evaluate Existing Habitat Conditions. Briefly, Phase I involves the coordination of field and office effort to:

a. Develop the categories within the descriptive parameters to the level of detail deemed possible and desirable for conducting the study for the species of interest (examples of parameters are given in Table 42 and examples of their categorical breakdowns are given in Appendix C).

b. Define the land uses in terms of these parameters.

c. Define the levels of habitat preferences in terms of these parameters; and

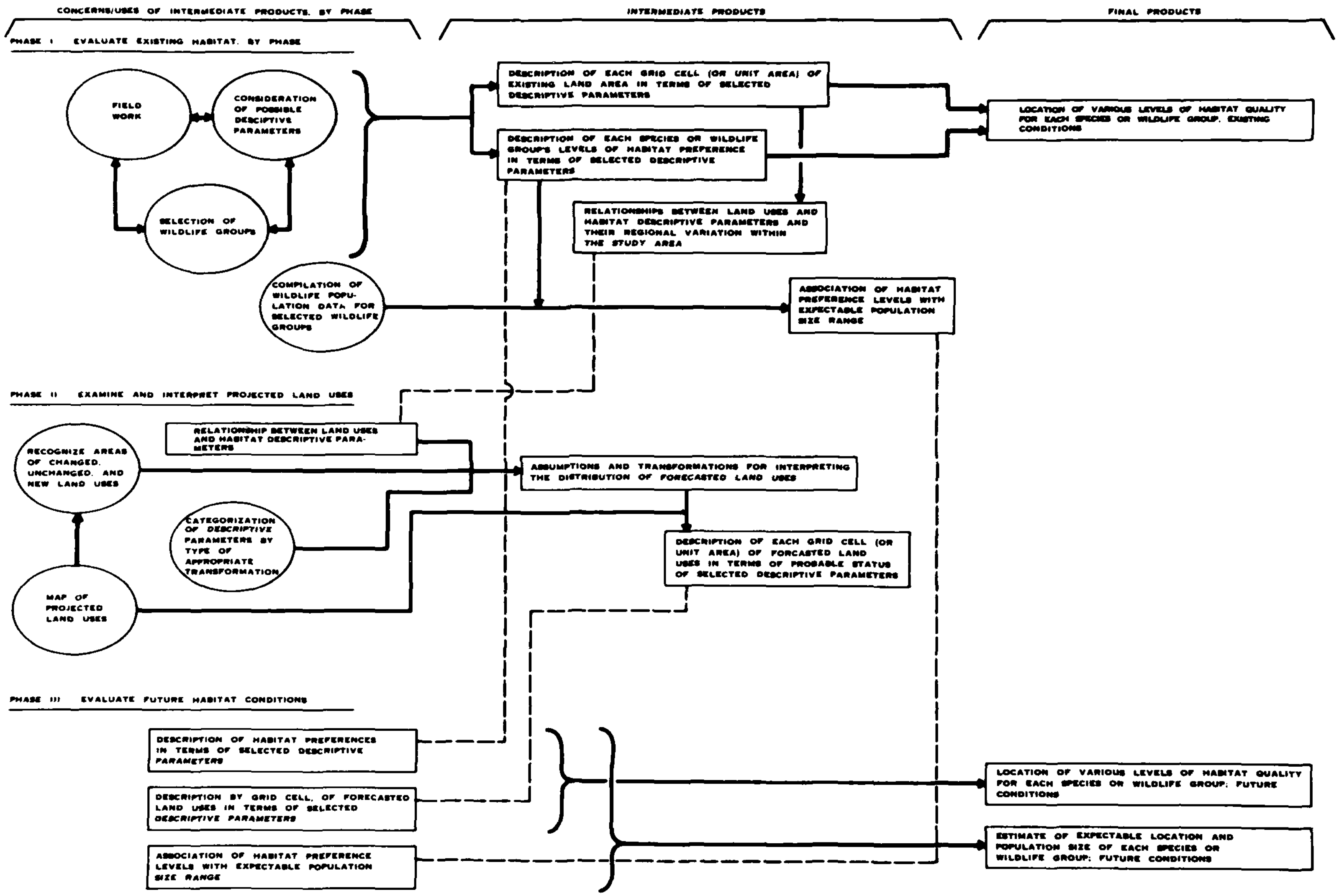

Figure 24. Concerns and products of each phase of the strategy recommended for interpreting probable future habitat conditions from projected land uses. (Circles represent basic needs to yield products, which are indicated by blocks; dotted lines indicate use of products in a later phase).

d. Evaluate the distribution and combination of parameters so as to locate which portions of the study area provide what level of habitat preference.

At the completion of Phase I, the location of the various levels of habitat quality would be known as would the area's relationships between habitat descriptive parameters and land uses. These relationships will be applied in Phase II to translate projected land uses into future habitat conditions. Phase I information would also include the location of areas of aesthetic or cultural significance; such information is important to evaluation of habitat under existing and projected land uses because such areas are frequently protected from development and if they are, they can provide useful habitat for some wildlife species.

Phase II: Examine and Interpret Projected Land Uses. Neither this phase nor the next (the final) can be undertaken if the future land uses have not been projected. The objective of this phase is to translate projected land uses into a description of the status of the various habitat components, i.e., the descriptive parameters established in Phase I.

First, the types and distribution of the projected land uses are compared with that for existing and/or any preceding target year projections to locate: (a) where changes have not occurred; (b) where changes have occurred; and (c) what and where any new land uses occur.

Then, lands in each of these three categories are examined and assumptions made as to what transformations to apply in order to translate the projected uses into a probable display of descriptive parameters. The assumptions take into account the localized variation of descriptive parameters within individual land uses that may be observed under existing conditions.* They also allow for the possibility that even though a site does not experience a change in land use, that there may be a change in some of the descriptive parameters: for example, as a result of vegetative growth or of a shift in the nature of human activity.

The development of the assump' ..s can be made easier if the descriptive parameters can be organized by categories that indicate what sort of transformation is appropriate; the kinds of categories that would be suitable, as well as the distribution of parameters among them would be influenced by information obtained on existing conditions. Examples of categories might be:

a. Descriptive parameters whose status would be transferred directly from a past condition. Parameters in this category would have the same status under the target year of interest as they had in the past conditions. Likely candidates for this category would be all

*In many cases, particularly in those where development pressures, including agricultural use, are evident, localized variation may be an indication of land suitability factors in the study area. These factors can be clues to such relationships as occur between soil and vegetation, that underlie habitat differences.

those parameters designated as significant features on Table 42. Significant features not included would be any for which there is some basis for anticipating a change in the future: for example, a thoroughfare may be expected to be upgraded or anticipated agricultural changes may be expected to result in loss of fencerows.

b. Descriptive parameters whose status would be obtainable directly from the map of projected land uses. This category would probably include a few of the parameters that relate land cover characteristics such as interspersion between cover types, edge quantity, and edge quality (Table 42).

In some cases, information on existing conditions could be helpful in assigning parameters status. For example, if, under existing conditions, land uses X and Y typically yield an edge of Z quality when they adjoin each other, then it may be reasonable to expect Z quality edge when land uses X and Y are juxtaposed in a forecasted land use plan.

c. Descriptive parameters whose status would need to be interpreted from the map of projected land uses. For sites in which a change in land use is forecasted, rationale for the interpretation of parameters in this category would largely be based on relationships observed under existing conditions, some of which may be localized within the study area. For example, sites converted to strip commercial might be expected to have the same set of site specific characteristics as existing strip commercial areas.*

For sites in which no change in land use is forecasted, rationale for the interpretation would come from expectable changes in the site's vegetation and human activities (e.g., vegetative succession, change in industrial base, change in population density of residential areas) and from any expectable changes in the land use of surrounding sites.

Table 42 parameters that might be included in the category of parameters whose status would need to be interpreted are:

*It is important to recognize that a site acquires some characteristics by virtue of its type of land use in the study area (or region within the study area), but that it acquires other characteristics by virtue of its particular siting. For example, all strip commercial lands in the area may have the same status for certain of the descriptive parameters (e.g., predominant cover type), but differ in the status of others (e.g., level of human activity or presence of water features); furthermore, the status of some of the parameters is more often due to the arrangement of land uses than to the characteristics of any one land use (e.g., interspersion).

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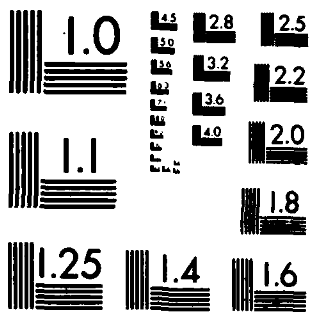

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(1) if the area is largely vegetated—the predominant cover type, the secondary cover type, age of predominant cover type, interspersion within predominant cover type, vegetative strata, and vegetative management practices.

(2) the human activity parameters.*

At the completion of Phase II, the assumptions and transformations for projecting the descriptive parameters associated with the forecasted land uses would be established and the transformations would be carried out.

Phase III: Evaluate Future Habitat Conditions. Activities in this phase would be similar to those conducted at the end of the first phase. The distribution and combination of descriptive parameters would be analyzed to locate areas of different habitat preference for the wildlife of interest. This phase would also include a comparison of whatever sets of conditions are being studied, for example: future and existing, alternative futures, or future with and without.

* Interpretation of the event intensity parameters (pollutant and noise levels) of human activities would probably be accomplished in four stages. First, to estimate the level class (e.g., high, negligible, etc.); second, to estimate the unimpeded distance range; third, to modify the unimpeded range to account for cover type characteristics so as to estimate the probable distance range; and fourth, if necessary, to estimate the cumulative event frequency as contributed to by additional activities in the surrounding area.

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APPENDIX A

SYNOPSES OF CASE STUDIES OF CORPS PLANNING DOCUMENTS

Contents

DICKEY-LINCOLN SCHOOL LAKES (New England Division)

Type/purpose: impoundment for hydropower, flood control, and recreation; in addition, redevelopment benefits will be realized.

General setting: Fairly remote area supporting relatively undisturbed ecosystem characterized by natural spruce - fir boreal forests interspersed with northern hardwoods and aquatic systems. The project area is gradually becoming a managed multiple use forest.

Projection categories:

Habitat Types (quality and quantity at target years)	Land Uses (trend projections)
Spruce-fir, mature	Forest
Spruce-fir, regeneration	Roads
Softwood-hardwood, mature	Industrial
Hardwood-softwood, mature	Urban centers
Hardwood, mature	Recreation
Hardwood, regeneration	Residential
Poplar-birch, all ages	
Bogs	Recreation Demand
Shallow fresh marsh	(available at 5-yr intervals
Miscellaneous (rivers, ponds, miscellaneous areas)	

Target years: Existing and Years 0, 10, 30, and 100.

Study period: Expected life of the project, 100 years.

Study area: Area of impoundment, area within two miles of maximum pool elevations, and area studied for transmission line project.

Projections

In general, project that the forest management program will increase and that wildlife will respond to an increase in disturbed areas (i.e. increase in early successional stages, edge, and ground cover); however, anticipate that changes will not be significant.

Habitat

Habitat conditions are evaluated for existing and for futures for both with and without the project. Evaluation is done using HEP methodology but with two modifications. The first accounts for the value that interspersion of habitat types has for wildlife populations: the modified procedures evaluate interspersion before and after mitigation and calculate an increase in management potential unit value due to interspersion. The second describes a procedure for determining the deer yard acreage required to mitigate deer harvest. The two modifications result in a significant reduction in number of acres required for mitigation as compared to the number determined by application of HEP. (i.e. 192,991 acres using HEP and 89,838 using these modifications).

Assumptions. (a) Habitats are presently occupied at or near maximum equilibrium populations and will continue to be occupied at that level unless the habitat is drastically changed. (b) Target years are selected on the basis of anticipated timber cutting cycle. (c) For practical purposes, conditions at Year 0 are assumed equal to existing.

Land Use.

Land uses are projected in a general way for the basin and county and are largely given as trend projections. Existing land use is inventoried by type, percent breakdown, distribution, population density, land ownership, and zoning controls.

Assumptions: (a) Given that about 86% of the county is in commercial forests and that zoning controls are in effect on more than 75% of the lands, then it is assumed that land uses are not expected to change significantly.

Future without the project

Anticipated habitat conditions are based on an estimation of expected future lumbering operations (selective cuts) and consultation with forest managers. Changes in habitat types would be caused by timber cutting and subsequent regrowth. Criteria are developed for evaluating potential habitat changes with regards to cutting cycles and regeneration stage of growth for each forest habitat type (e.g. with a 10-year cutting cycle and a 40-year regeneration stage, 25% of the acreage would become mature every 10 years).

Anticipated land uses were projected based on: a) comprehensive plans and goals from all appropriate agencies and authorities, b) consideration of overall trends, c) overview of factors that would likely impact on land use and assessment of what the general impact would be. No significant changes anticipated; the major trend would be toward more intense management and use of forests for commercial purposes.

Future with the project

Habitat conditions are estimated by criteria similar to that for without the project; however, criteria are modified somewhat in that cutting practices are expected to be different since forest managers would need to more intensively manage lands remaining outside the project area. It is assumed that no timber harvesting would occur outside of the impoundment between Years 0-10 because the market would be saturated with wood from the impoundment area.

Land uses are anticipated essentially through identification of where conflicts with the without-project land uses would occur: relocation of residences, limitations of uses on project lands, increased demands on remaining lands, and floodplain development. The net effect would be an extension and increase in zoning controls.

Impacts

Measure

The net difference between the annualized future with and the annualized future without projections is the measure of the impact of the project. This measure is expressed by habitat type in habitat units. Since it is assumed that the future without is not significantly changed from existing, then the impact of the project is, in effect, the impact on existing conditions.

Additional consideration

The most direct impact of the project is the inundation which will cause wildlife populations to die or be displaced. The survival of the displaced will depend on the availability and carrying capacity of surrounding habitat. In that adjacent habitats are already occupied at or near carrying capacity, an adjustment which cannot be estimated, will result.

Although changes in total standing crop cannot be specified, some assumptions can be made.

Assumptions. In that 20% of the acreage within the lakes project study area will be inundated it may be conservatively assumed that without wildlife management measures: (a) for species with non-specific habitat requirements there would be a 20% reduction in their total standing crop; (b) for species which are more specific in their habitat requirements, the change in standing crop may be greater or less than 20% depending on what habitat the species occupies; (c) any reduction in mean productivity outside of the impoundment should return to normal within a few years.

Treatment of Wildlife

Consideration is given to wildlife essentially through projection and assessment of habitat condition, i.e. the quality and quantity of that habitat. Habitat types are assessed in terms of their value to a number of species selected as being representative of that habitat type. All species are considered equally important.

Assessment of habitat condition took into account vegetational productivity, vegetational damaging agents, wildlife habitat preferences and needs, wildlife species range, indirect impacts of forest management (increased roads, erosion, and silt).

WILMINGTON HARBOR - NORTHEAST CAPE FEAR RIVER

(Wilmington District)

Type/Purpose: Navigation improvement for deep draft navigation, related national economic, and conservation of environmental quality.

General Setting: Navigation channel in area consisting primarily of wetlands lying between the river and an area of upland forests which is industrially owned or has high potential for development.

Projection Categories:

Ecosystems (by acreage in study area)
Swamp Forest
Fresh Marsh
Mixed Hardwood/Pine
Longleaf Pine/Turkey Oak
Industrial/Urban
Dredged Material

Ecological Criteria

Net primary productivity (grams carbon/acre/yr)
Energy flow
Habitat diversity → (in relative values)
Rarity
Game value (in game points by species; expressed relative value of habitat types for selected game species).

Target Years: Existing (1980) and Year 50.

Study Period: Expected life of project (50 yrs).

Study Area: Defined based on past land use changes.

a. Primary: Area where further navigation improvements in the Northeast Cape Fear River will affect the most significant economic and ecological changes. This area consists of the 4000 acres of lands adjacent to the 8 river miles above the section where the navigation improvements are needed.

b. Secondary: Area in which, from an overview perspective, further navigation improvements would be expected to effect some influence on the economy and ecology. This area consists of the area adjacent to the lower Cape Fear and Northeast Cape Fear basins.

Special Considerations:

The main intent of the environmental analysis is to substantiate the thesis resulting from the following sequence of observation and logic:

a. that the areas resources have been managed in a conflicting manner; i.e., that the use of the river for navigation has been detrimental to the environmental quality of adjacent wetland and wilderness areas;

b. that the resource management conflict will continue whether or not the project's navigation improvements are undertaken; i.e., the difference between the projected acreages by ecosystem for future without and the NED plan is minimal (under the NED plan 3 acres that would otherwise be fresh marsh would become industrial/urban);

c. that the EQ plan would reduce the conflict in resource use by providing protection for all wetlands (and a small amount of uplands) in the primary study area.

The area to be protected amounts to 70 percent of the study area and is termed a critical ecological zone (CEZ) because it is believed that this area functions as an inseparable unit of national significance.

The environmental analysis is undertaken through two general approaches to describe conditions and project effects through time. In one approach, the environmental considerations are expressed through data, narrative descriptions and pictures. In the other approach environmental conditions are described according to criteria selected to reflect environmental quality.

Projections

Anticipation of future conditions is based on four major assumptions about population growth:

a. that urbanization will be the controlling factor in environmental quality;

b. that in-migration will continue to be the dominating force in population growth in the area and that therefore the rate of growth will be substantially higher than that projected by OBERS;

c. that projections of economic activity can be made by using the correlation coefficient of the historical relationship between the growth of commerce, population, and personal income;*

d. that because of zoning and access, the undeveloped area upriver to the project would logically be developed and that therefore this area is the primary study area.

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*Multiple correlation analysis determined that growth in commerce and population (independent variables) and personal income (dependent variable) were strongly related. Comparison of changes in the relationship of those three variables to periods of Federal improvement in navigation demonstrated that trends in the area's development and economy have been closely related to commerce moved on the river.

Development of the most probable future land use was based on historical land use patterns; to simplify the predicting process, three alternative futures were described. All three futures incorporated a common set of assumptions, but varied the extent to which they would occur: that upland bluffs would be developed, that some filling of wetlands would occur (i.e., violations of permit authority), that ecotonal intrusion will continue on the wetland perimeter, and that the natural beauty and wilderness character of the area would be fragmented.

a. <u>maximum development</u> -

in this scenario it was assumed that economic development pressure would override the environmental constraint of concerving the wetlands, that economic benefits of constructing river access across wetlands would outweigh environmental losses, that permits would be issued without regional planning and, that the value of wetlands would be degraded.

The scenario was based on a map of regional development, year 2000, prepared by the Cape Fear Council of Governments, which indicated that all of the primary study area is classified urban or industrial with conservation areas relegated to more distant areas in the region.

b. <u>maximum environmental maintenance</u> -

in this scenario it was assumed that new laws would constraint development actions, that no permits would be granted to allow industry to cross the wetlands, and that this would limit industrial development potential.

The scenario was guided by a map developed by the Wilmington-New Hanover Planning Commission for a 10-year projection period. Acreages of land use in each ecosystem were assumed to reflect significant community stewardship of area resources.

c. <u>probable development</u> -

this scenario describes the land use likely to occur between the extremes for maximum development and for maximum resource maintenance. It was expected that historical trends in land use development would persist but with lesser intensity, that development would continue to move up river, that better and more access and deep navigation would occur to accommodate more traffic. In this scenario, assumed losses and gains are based on the land area needed to accommodate the projections made for industrial growth and on the belief that existing controls would provide some protection for wetlands.

The scenario was based on a map prepared by the Cape Fear Council of Governments.

Impacts

The channel improvements planned for the project would be the same whether the NED or the EQ plan were implemented and the significant direct impacts of these improvements would be slight (disruptive fish and shellfish propagation on three acres). The essential difference between the two plans is the acreage which would be affected.

Impact on Environmental Quality

A major concern of the impact assessment then was to compare the effects of the EQ and NED plans on the without project condition. This was done by a procedure in which ecological criteria were defined and were evaluated as to their expected levels under the without project condition, the EQ plan, and the NED plan; in this way the effect of each of the three conditions on environmental quality could be compared. Use of this procedure indicated that implementing the NED plan would reduce environmental quality in the study area by less than one percent and that implementing the EQ plan would result in a net increase of nine percent.

Descriptive Assumptions

In addition to the process to compare effects on environmental quality, the impacts on terrestrial and aquatic ecology were anticipated in a general, descriptive way since it was stated that it would be impossible to predict the exact magnitude of changes.

a. impacts on terrestrial ecology in the CEZ:

- habitat diversity and quality will decline due to urbanization. The decline would be realized in four ways:

  i. direct destruction of forest and wetlands.
  ii. preemption of habitat by structures.
  iii. alteration of patterns of habitat distribution.
  iv. alteration of background levels of environmental contaminants.

- most uplands will be developed
- wetlands will be fragmented by industrial access corridors with the result that migration corridors would be gone.

b. impacts on aquatic ecology in the CEZ:

- water quality may decrease because of urbanization and traffic.
- spawning and nursery habitat would decrease.

Visual displays

As part of the EQ plan, industrial access corridors were tentatively located. The environmental impacts of the corridors on a group are identified using an environmental effects matrix and individually using an environmental factor profile.

Treatment of Wildlife

The study is meant to be all encompassing of vertebrate and invertebrate life including birds, mammals, amphibians, reptiles, insects and crustaceans, with special consideration for game and rare species. Actual treatment is fairly superficial, but is probably appropriate to the scope of the analysis, i.e., effects on environmental quality.

Vegetation communities are defined and briefly described as to the major species of plants and animals that are known to or are likely to occur and as to ecosystem functions.

Mammals potentially occurring in environments of the study area are listed by habitat type (e.g., forest) and with specific habitat (e.g., open pine forest) indicated.

Birds potentially occurring in the study area are listed with indication of potential presence and status (summer resident, permanent resident) within various habitat types.

Species considered endangered or threatened on the national or state level and that could exist within the study area are listed.

For game species, species or species groups were selected and the value (food value plus cover value) of each habitat type for each species was judgementally rated. A maximum of 5 points each was allowed for food value and cover value, or a total of 10 points for habitat. In this way, the relative value of various habitat types for game species is determined.

TWIN VALLEY LAKE (St. Paul District)

Type/purpose: Impoundment for flood control, recreation, and fish and wildlife development.

General setting: Predominately agricultural area; river valley supports mixed hardwood forest.

Projection categories*:

Habitat Types
Upland hardwood
Lowland hardwood
Oxbows
Upland brush
Lowland brush
Grassland
Cropland
Streambank
Wetlands

Target years: Existing and Years 0, 5, 10, 20, 50, and 100.

Study period: Expected life of the project, 100 years.

Study area: Area of impact or project area, divided into planning segments: conservation pool, take line area, upper floodpool, lower floodpool, south recreation area, north recreation, structures/spillway area. Areas being considered for compensation also evaluated.

Special considerations: Analysis includes study of compensation areas; initially began with five areas for consideration and finally selected two of these areas as being adequate for compensation.

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*A land use plan would be developed in conjunction with preparation of a master plan for resource management in later studies. This plan would take into account any potential land use conflicts and would be developed to minimize any such conflicts.

Projections

Habitat conditions are evaluated for existing and for futures for both with and without the project. Evaluation is done using HEP methodology. Past and current trends in land use change and natural succession are studied. Relationship between trends in legislation, education, leisure time, governmental regulation, etc. and changes in land use are considered.

Assumptions: (a) no change in climate during the study period, (b) no employment of habitat management measures, (c) losses from floods greater than the 100-year flood are not considered.

Future habitat conditions without the project: The major change in land use to be expected is an increase in cropland, however no change is projected for habitat conditions over the period of analysis. Procedure for anticipating increases in cropland: (a) identify the potentially clearable and drainable areas, (b) select from those areas those that would probably convert to cropland by considering factors of size, access, ownership, effort required for conversion, and trends in agricultural programs.

Assumptions: (a) any changes occurring are assumed to balance out by the end of the study period, (b) trends point to a future which would preserve and/or restore wildlife habitat, (c) losses would be balanced to a large extent by benefits from erosion control problems, (d) clearing and draining would continue but by Year 100 there would be a return to present conditions, (e) it is unlikely that cropland would revert to more natural habitat in the period of analysis.

Future habitat conditions with the project: Projection of future with the project involves analysis of natural succession and habitat changes resulting from loss of lands to the project. Regeneration of grasses, forbs, shrubs, and trees is considered. Division of the floodpool into upper and lower floodpools facilitates analysis (division is made midway between total floodpool and conservation pool).

Projection of probable habitat changes during study period is simplified by identifying what habitat change transitions could be possible by way of natural succession and filling of the reservoir. Changes are estimated in percentages and converted to acres.

Assumptions: (a) no increase in cropland will recur, (b) in general, regeneration affects a reduction of habitat losses, (c) habitat loss is determined by "professional judgment" based on flood duration-frequency curves, elevation maps, and field notes, (d) the midpoint elevation is used to divide the floodpool as that elevation corresponds with the 20-year or greater floods and it is assumed that following flood damage and habitat loss that vegetation would begin to stabilize in about 20 years.

Impacts

The net difference between the annualized future with and the annualized future without projections is the measure of the impact of the project. This measure is expressed by habitat type in habitat units. Since it is assumed that the future without is essentially unchanged from existing, then the impact of the project is, in effect, the impact on existing conditions.

Adjustment for indeterminable effects.

The procedure recognizes that the determination of impacts by way of the HEP analysis has not taken into account several "indeterminable effects." Adjustment is made for those effects after an evaluative comparison of the number of habitat units that could be gained from management in the compensation areas and the project area to the number of habitat units needed as a result of terrestrial habitat losses in the project area. Comparison of habitat units lost and gained requires development of a compensation ratio which incorporates a critical factor assigned to habitat types having an as yet unconsidered ecological value (e.g. deer wintering habitat).

The number of habitat units gained is reduced by 40% to account for the indeterminable effects.

Assumptions: (a) Reduction includes a contingency factor of 20% to allow for indeterminable problems in the implementation of the compensation plan (This 20% is similar to the project costs contingency factor).
(b) Reduction includes an adjustment of 20% to account for lack of refinement in the study, for indeterminable effects of factors not included in the evaluation, and effects dependent on future decisions.

Indeterminable effects and uncertainties:

a. induced development including more intensive development in the downstream floodplain area and development near the reservoir,

b. habitat lost to construction,

c. habitat degradation due to pressure on resources and to recreational use,

d. delay in realization of benefits from management measures,

e. results of aquatic habitat loss

f. real estate acquisition take line (position not established)

g. response of populations to habitat management

h. flood control

i. aerial photography resolution and the definition of habitat types

j. cumulative impacts through the ecologic web

Treatment of Wildlife

Consideration is given to wildlife through projection and assessment of habitat condition, i.e. the quality and quantity of that habitat. Habitat types are assessed in terms of their value to a number of species selected as being representative of that habitat type. All species are considered equally important.

The monetary evaluation procedures (MEP) are used and do include estimates by species (where possible) of the existing and future densities in primary habitat. The MEP analysis can provide an estimate for mitigation, but reliance is placed on the more satisfactory habitat unit assessment to justify mitigation.

The MEP analysis was not directly applied in assessing project impacts or developing the compensation plan.

LOUISVILLE AND BIG BLUE LAKES
(Louisville District)

Louisville Lake

Type/purpose: Impoundment for flood control, general recreation, fish and wildlife enhancement, water supply, and water quality control.

General setting: Sparsely populated area. Upland topography is level to gently rolling. General farming practiced on the more fertile bottomland soils.

Projection categories:

Habitat Types*
Upland woods
Bottomland woods
Old fields
Row crops
Small grains and hay
Pasture
Fence row
Riparian
Ponds

Target Years: Existing, Years 0, 25, 50, 75, and 100.
(Year 0 = 1985)

Study period: Expected life of the project, 100 years.

Study area: Projections are made for each of the segments within the project area. The project area was divided into these segments: construction area, summer pool, flood pool, flood pool to acquisition line, recreation areas, and mitigation land.

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*Not included are residential areas, roadways, and acres of streams.

Big Blue Lake

Type/purpose: Impoundment for flood control, recreation, water quality control, and water supply.

General setting: Rural character with considerable ecological diversity. Uplands intensively farmed; major woodlands occur on valley slopes and river borders. Wooded bottomlands and slopes are interspersed with cropland.

Project categories

Habitat Types*
Upland forest
Bottomland forest
Streamside
Fencerows
Wetlands
Pasture
Cropland
Old fields
Ponds

Target years: Existing, Years 0, 25, 50, 75, and 100.
(Year 0 = 1985)

Study period: Expected life of the project, 100 years.

Study area: Projections are made for the project area. The project area included the damsite, specific use recreation lands and wildlife mitigation lands.

*Not included are residential areas, roadways, and acres of streams.

Values and Projections

Land uses and changes in land uses are considered. The various land uses are evaluated as to their value for wildlife habitat, but some are assumed to have no value. For example, acreage changes in residential lands are projected, but because residential land is assumed to have no value for wildlife, then conversion of habitat acres to residential acres is considered a loss of habitat.

Habitat types are described in terms of area and habitat value under existing conditions and for futures for both with and without the project. The description is expressed in habitat units (No. Habitat Units = Habitat Quality, acres x Habitat Quality).

Existing habitat conditions are evaluated by acquiring data through HEP field procedures and by modifying the HEP data analysis to derive "more realistic" habitat values for lineal habitats (such as fence rows and riparian areas) and cropland habitats. HEP-assigned values of lineal habitats are upgraded to better reflect their ecotonal value by multiplying by a factor which takes into account the value that the nabitat would have if it could cover an acre. It was assumed that large areas of cropland, which provide little cover and food for only a part of the year, can in no way attain the value of the surrounding more diversified habitats. Allcropland in excess of 25 percent of the project was devalued by 50 percent of its assigned value.

Projections of habitat conditions over the study period are made based on expectable changes from existing habitats.

Management potential values, calculated for each habitat type, assume that the maximum potential of 100 can be achieved.

Future without the project

Changes in quantity. The without-project land use acreage projections are based on current land use patterns, soil types, soil capabilities, and economic and demographic trends. Areas judged to have land use change potential are identified from onsite observation. The basic assumptions in speculating land use changes are that:

a. Domestic and export demand for food and fiber will continue to increase.

b. Project lands will be used more intensively for agricultural production.

c. Agricultural land prices will continue to increase.

d. Trends toward larger farming units will continue.

Additional rationale in anticipating land use changes are:

a. Dominant factors in conversion of woodlands to cropland are soils, drainage, flooding, accessibility, and slope.

b. Bottomland woods will most likely be converted to corn and soybeans while uplands will be converted to hay and pasture.

c. Land use attitudes of current landowners are not considered; ownership patterns and attitudes will change but are impossible to project.

d. Trends toward larger farms, fields, and farms implements will result in the loss of fencerow and ditch bank habitat.

e. Trends toward more and larger ponds will likely result in some loss of hay and pastureland.

f. Economic pressures will likely result in decreases of old fields.

g. Residential development will occur particularly in wooded uplands adjacent to established roads.

h. Changes in land areas occupied by roads, roadsides, streams, and streamsides are considered. (In these projects they were not significant.)

The areas that are judged to have land use change potential are those that are expected to be changed by the end of the projection period. Existing and Year 100 land use acreages are plotted and these two points are connected by a straight line to derive intermediate year projection. In view of the uncertain nature of land use projections, it is assumed that this method is as valid as any other.

Changes in quality. The without-project values for habitat quality of each habitat type are assumed to be the same as those determined for existing conditions.

Future with the project.

Changes in quantity. With-project changes in land use are anticipated by imposing project conditions on the without-project land use projections. This projection accounts for all substantial losses and gains to the terrestrial habitat from direct development and operation of the project. Changes in land use that may be induced by the project (e.g. residential development attracted to lake area) are not considered.

Changes in quality. It is anticipated that recreational pressure and water level fluctuation will affect habitat quality. Therefore, habitat values assigned for existing conditions (and retained for without-project conditions) are adjusted to account for these disturbances:

a. Recreation pressure --

(1) The habitat quality of areas to be used for construction of roads and boat ramps is assumed to be zero.

(2) The habitat quality of areas to be used for campsites is reduced by 10%.

(3) The habitat quality of areas adjacent to game and play areas (i.e. lying within a zone double the size of the recreation area) is reduced by 5%.

b. Water level fluctuation --

(1) The habitat quality of areas in the zone affected by frequent fluctuation and wave action such that vegetation cannot be established, is reduced to zero.

(2) The habitat quality of areas in the zone affected by fluctuation to the extent that only tolerant grasses can survive, is devalued by 40% of that assigned to the old field habitat.

(3) The habitat quality of areas in the zone affected by fluctuation such that sapling-sized species can survive is devalued by 30 % of that assigned to the old field habitat.

Wetland habitat is defined as those areas that would have up to two feet of water when the lake is at summer pool elevation. Based on wetland development and anticipated sedimentation, wetland acreages existant at 25-year intervals are estimated. Habitat values are assigned based on the age of the wetland.

Impacts and Compensation

The difference between the net annualized loss of habitat units without the project and the net annualized loss of habitat units with the project is the impact that may be expected due to the project. This deficit quantitatively expresses in habitat units, the compensation needed.

For each habitat type, the acreages that would be needed, under maximal management practices, to compensate for the loss can be estimated by dividing the compensation need calculated for that habitat tyne by the management potential value.

This procedure enables comparison of relative need for compensation by the project alternatives. The calculated deficit of habitat units should not be automatically converted into acres needed for compensation; it merely provides guidance as to compensation need.

UNION LAKE (St. Louis District)

Type/purpose: Impoundment for flood control, water supply, recreation, fish and wildlife conservation. Benefits would include area development.

General setting: Gently rolling topography. Irregularly shaped crop and pasture fields in bottomlands and mixed oak stands in tributary draws.

Projection: Scenario of conditions expectable at Year 2020. (Target Year approx. 45). Estimated the percent losses in habitat value that would accrue over the period of analysis within each planning segment. Also, developed a method for simulating reservoir-induced residential development on off-project lands.

Habitat Types
Bottomland forest
Upland forest
Pasture
Cropland
Riverine
Impoundments

Study area: On-project lands included as planning segments the joint use pool, the flood pool, other project lands. Area of off-project lands included those within 300 ft. of take-line and those downstream of the dam.

Study period: Existing (1974) to 2020.

Terrestrial Habitat Evaluation

Existing

For existing conditions a habitat value and total number of habitat units (HU) were determined for each habitat type in each planning segment through use of the USFWS Habitat Evaluation Procedures (HEP). A value of HU/acre was calculated for each planning segment.

Future with the project

1. Projected the number of HU expected to be lost because of the project due to:

a) inundation (joint use pool and flood pool)

b) recreational development (initial development and future development)

c) reduced carrying capacity

d) off-project land use changes

The number of HU expected to be lost within each planning segment was calculated as:

HU loss = HU/acre x acres x Estimated % loss of value

Where HU/acre was the value calculated for existing conditions.

2. Projected the number of HU expected to be gained due to wildlife management programs. The number of HU expected to be gained by management was calculated as:

HU gain - (10 - (HU/acre)) x acres

3. The difference between the total HU loss and the total HU gained was the net HU loss.

<u>Replacement need</u>

The acreage of similar land needed to replace the total loss was calculated as:

Replacement = net HU loss/ (10 - (HU/acre))

This calculation assumes that the maximum management potential value of 10/acre would be achieved.

<u>Assumptions for estimated percent loss of habitat value on project lands</u>

1. Inundation

a) The lands to be inundated in the area of the <u>joint use pool</u> were not considered to be a total loss of terrestrial habitat. The edge of the lake would be used to some extent by amphibians, aquatic reptiles, and mammals; the rest of the lake would be used by waterfowl. Terrestrial habitat loss within the joint pool was estimated to be 98%.

b) Within the <u>flood pool</u>, percent losses were estimated based on flooding frequency. Areas to be flooded at least once every 2 years were estimated to be reduced in value by 25%. Areas to be flooded about every five years were estimated to be reduced in value by 10%.

2. Recreation

a) The number of acres scheduled for <u>initial</u> intensive recreational development was determined. It was estimated that the habitat value of those lands would be reduced by 25% due to development and human disturbance.

b) The number of acres scheduled for future development was determined. It was estimated that 30% of that area would be intensively developed; because of the uncertainty of this development, the loss of habitat value on the area to be intensively developed was estimated to be 10% rather than 25%.

3. Reduced carrying capacity

It was recognized that the project area carrying capacity would be reduced since bottomlands are the key area for the productivity of many species. The magnitude of reduction and over what area could not be determined; conservatively it was estimated that habitat value would be reduced by 10% on all project lands above joint use pool (and not within the 2-year or 5-year flood pool area).

Assumptions for estimated percent loss of habitat value on off-project lands

1. Flood protection

Protection of the downstream area would result in intensified agricultural production and so would decrease the wildlife habitat value through loss of interspersion and forest cover.

a) In downstream areas where a high degree of protection would be afforded (an extent of 32.5 miles - the area between the dam and the downstream river confluence) it was estimated that the habitat value would be reduced by 20%.

b) In downstream areas where partial protection would be afforded (the area between the downstream confluence and the confluence with the Mississippi) it was estimated that Union Lake would provide 15% of the protection. It was estimated that the habitat value would be reduced by 205 x 15% (or 3%).

2. Recreational development within 300 ft. of take-line.*

It was estimated that the habitat value in this off-project area would be reduced by 25%. The estimate was derived by a methodology developed to simulate the amount of reservoir-induced shoreline residential development

*The 300 ft. distance was chosen because the only previous study of reservoir-induced residential development had examined only the area within 300 feet of project lands and therefore, the only information available was confined to this 300 ft. area. This previous study was conducted by R.J. Burby et al. of the Water Resources Research Institute at the University of North Carolina. In reading the report by Burby et al. it appeared to me that the study had actually examined the area within 2½ miles of project lands. I contacted Dr. Burby for clarification. He said that they had studied attractiveness location factors within 2½ miles of projects, but had determined a different set of factors for the shoreline area (within 300 ft.) and the surrounding area (300 ft. to 2½ miles).

that would occur. (This methodology is detailed in Appendix B).

Assumptions for estimating percent gain in habitat value on project lands

Project lands minus those areas scheduled for inundation, development (roads, buildings etc.), and state park define the area available for wildlife management. It was assumed that with management that the value of this land could be increased to the maximum of 10 HU/acre.

The area to be managed consisted largely of less fertile uplands and so the same HU/acre rating in uplands and bottomlands is not entirely comparable. However, it was assumed that the transfer of uplands to public use and management might make up the difference.

MARYSVILLE LAKE (Sacramento District)

Type/purpose: Impoundment for flood control, power, irrigation, general recreation, and fish and wildlife purposes.

General setting: County is urban, area to be inundated is primarily agricultural and open land.

Projection categories, land use and resources:

Land Uses	Plant Communities	Wildlife Resources
Urban	Oak Digger pine woodland	Big game
Agriculture, irrigated	Sycamore-alder-oak (riparian woodland)	Furbearing animals
Agriculture, non-irrigated		Waterfowl
Open space & recreation	Willow cottonwood (riparian woodland)	Upland game
Rural residential agriculture		Non-game birds
Forest	Chaparral	Reptiles and amphibians
Air Force Base	Grassland-agriculture Miscellaneous (water surface, tailings, urban, etc.)	

Target years: Present, Project Year One (1990), after 25 years (2015), and after 50 years (2040).

Study period: Expected life of the project, 100 years.

Study area: Projections are made for the county and for the project area (project lands).

Special considerations: Future water use levels are a problem as there is no forecast of water needs for the county. Since no projections are available, a most probable condition of water use was development through conferment of agencies.

Projections

Conditions are described for existing and for futures for both with and without the project for these resource categories: 1) land and water uses, 2) ecosystems, 3) wildlife resources, 4) aquatic resources, and 5) recreational resources. Descriptions maintain a perspective regarding relationship to regional conditions.
Assumption: Descriptions of the resource categories are developed for the first 50 years; for the second 50 years it is assumed that description will remain constant because of uncertainties in making projections that far into the future.

Future land use without the project:
Projected county population increases are the driver in describing future land use trends, but consideration is also given to direct and indirect impacts of anticipated regional population changes.
Assumptions: (a) future land uses at the end of Year One (1990) will be in accordance with that for 1985, which are described in the County General Plan. (b) county population projections are available for the first 25 years (2015); it is assumed that those trends will continue for the next 25, therefore population projections were developed through Year 50.

Future land use with the project:
Assumptions: (a) land uses will generally be similar to that described for without the project. (b) project will have no impact on the long-range population trend. (c) the lake will cause population densities in that area to increase at a faster rate than in the rest of the country, assumes a change in density from 0-2 to 4-8 people/acre.

Impacts

(Difference between future with and future without)

Overall, assumes that for the future with, there is no major departure from future without project conditions; the differe ce with the project would be where the changes would occ r and with wha tensity. The major differences to be expected relate to: Federal land a uisition for the project, construction activities, and lake recreation based activities.

For wildlife, impacts are given in estimated number of individuals realizing impact except for fish (given in angler hours and angler days) and waterfowl (given in nesting pairs and use days). For plant communities, impacts are given as estimated number of acres.

Treatment of Wildlife

Consideration is given to wildlife through projection of ecosystem conditions for with and without the project at each target year. Projected plant community changes are based on projected land use changes and on successional changes. Project plant community changes are the driver for habitat changes. By applying anticipated plant community changes to baseline conditions the anticipated patterns of the communities can be mapped and the quantities of habitats estimated. The quality of habitat is then assessed to evaluate its carrying capacity or value for wildlife. Assessment of habitat quality includes attention to estimated human use/disturbance. Wildlife resource considerations include (where appropriate and possible): Department of Fish and Game predictions, densities, harvest pressure, range, habitat preferences.

Future ecosystems without the project:

Plant community conditions are based on anticipated changes in successional stages (stability), land use, intensity of recreational use, and water use.

Wildlife resource conditions are estimated in terms of population levels; where possible, densities and diversities within plant communities are developed. For some species, population levels are projected by using workable estimates (e.g. 7.5% reduction of deer by Year 25 and 15% by Year 50). For other species the best possible estimation can only be given as a general description of anticipated trends (e.g. steady decline, slight gradual increase). Estimates anticipate hunting and fishing levels and take into consideration the influence of regional recreational facilities.

Future ecosystems with the project:

Plant community conditions are based on anticipated changes in successional stages, land use, recreation use, water use and:

(a) losses due to construction and inundation
(b) project-induced changes outside of the gross pool and in the county
(c) changes expected to occur through time in the project area, for example vegetative recolonization on construction damaged areas and increased stress from intensity of recreational use.

Assumption: That outside of the project area that losses of plant community types to various land uses should be similar to those projected for without the project.

Wildlife resource conditions are assumed to be basically the same as for without the project with the major exception of losses of habitat acreages in the gross pool area. Anticipated indirect losses are described in a general way.

COTTONWOOD CREEK PROJECT: DUTCH GULCH AND TEHAMA LAKES (Sacramento District) *

Type/purpose: Two multipurpose impoundments, authorized for flood control, municipal and industrial water supply; irrigation, general recreation, and the enhancement of the anadromous fishery.

General setting: Predominately rural with some urbanization in proximity to interstate highway and rail access. Topography varies from rolling hills to steep slopes.

Land use projection categories (Cottonwood Creek Basin):

Agriculture

Subtropical fruits
Grain and hay - irrigated
Grain and hay - non-irrigated
Pasture - irrigated
Grazing - non-irrigated
Deciduous fruits and nuts
Deciduous fruits and nuts/field crops
Vineyards
Rice
Field crops
Idle
Truck and berry

Native

Mineral resources
Water resources
Riparian vegetation
Grassland and oak woods
Wetlands

Urban

Urban
Residential - pasture
Parks and recreation

Wildlife projection categories:

Fish (particularly king salmon and steelhead trout; but also striped bass and American shad)

* Synopis prepared from draft materials. All other planning studies in this Appendix were reviewed through completed documents.

Wildlife Habitat cover types

Wildlife:

Deer
Rare and Endangered Wildlife
Waterfowl and shorebirds (mallard and wood duck)
Upland Game (quail, turkey, pheasants, grey squirrel, jack rabbit, brush rabbit, bandtail pigions).
Furbearers
Other Birds (raptor and owl species, osprey, all others).
Other Mammals (mountain lion, black bear, rodents, bats).
Reptiles and Amphibians

Target years:

Existing (1977), 1990, 2040.

Study period: Life of the project, 100 years. However, all scenarios assume no additional land use changes after 2040.

Study area: Cottonwood Creek Basin subdivided into three areas: (a) area authorized for Dutch Gulch Lake; (b) area authorized for Tehama Lake; (c) the Lower Cottonwood Creek Floodplain (this area further subdivided into three reaches).

Projections

Probable project-induced effects on fish and wildlife resources are estimated by identifying the expected land use changes that would result in habitat modification or destruction. Emphasis in developing the projections is on determining probable conversions of native vegetation, particularly riparian, to agricultural or urban use. Once without project conditions are described, the project outputs (flood protection, recreation, employment, etc.) are imposed and the probable project-induced land use changes estimated.

Without project conditions:
For without-project conditions, three alternative scenarios are developed. These depicted a range of possible future conditions based on different sets of assumptions regarding basic factors affecting land use decisions by public and private entities. All three scenaries assume that land use changes would occur gradually from present (1977) until 2040, and that no additional changes would occur after that time. All scenarios involve conversion of native vegetation to agricultural use as result of urban-suburban encroachment on adjacent agricultural lands. The three scenarios may be briefly described as:

(a) minimum growth scenario - illustrates a future guided by serious resource constraints and emphasis on preserving environmental amenities by carefully planning urban growth.

(b) moderate growth scenario - depicts conditions as they might be in an era of steady economic growth where the middle class has sufficient resources to determine their life style, and where government guides rather than restricts development.

(c) maximum growth scenario - characterized by a booming economy with few resource constraints and minimal restrictions on development by government.

The most probable future is to be based on public response to the three. Prior to public review, the minimum growth scenario was tentatively picked as the most probable future.

With project conditions:

In the immediate project area it is considered that much of the land would be greatly changed through inundation. The lake is also expected to induce suburban development on private lands adjacent to public lands; the net increase would depend on which growth scenario occurred. In the flood-protected downstream areas it is expected that even though developments would be located closer to the stream, that the amount of riparian vegetation and agricultural acreage would not change significantly from without project conditions.

In general, under the minimum development scenario, it is assumed that the project would have no impact on the long-range population trend of the basin, but that it would have some effect on the distribution of populations because post-project suburban development would be attracted to the lakes.

The major assumptions developed for the immediate project area for each of the growth scenarios are included in a separate section; they indicate that consideration was given to a wide range of social and economic factors as well as capabilities relating to the natural environment (e.g., energy supplies and costs, soil suitability for septic tanks, profit in livestock, county policies).

Impacts

The major difference between the with and the without project futures is in where the changes would occur and with what intensity. Regardless of scenarios, the major differences to be expected relate to extent of development, which in turn would be influenced by soil suitability, topography, water availablilty, gasoline and electrical shortages, and construction costs. Although development would be encouraged in the floodproofed areas, impact on riparian vegetation would be expected to be minimal since county ordinance prohibits removal of riparian vegetation.

For wildlife, habitat would be lost to innundation and some additional habitat would be lost to project-induced residential development on adjacent lands. Native vegetation would be modified at developed recreation sites, but on remaining project lands and on lands to be aquired specifically for wildife mitigation or enhancement, the habitat value would be preserved or enhanced.

Treatment of Wildlife

The projection of wildlife futures is based on habitat use under existing conditions and expected trends in habitat particularly as affected by land use changes. Where possible, wildlife resources are estimated in terms of population levels or use days; however, for some wildlife groups, the best possible estimate can only be given as a general description, as for example, general loss in number of reptile species or slight increase in number of a particular speicis. Changes in wildlife condition are perceived through changes in habitat and take into account estimated human use and disturbance. Wildlife resource considerations include: Department of Fish and Game prediction, densities, harvest pressure, range, habitat preference, and carrying capacity. Future wildlife habitat and wildlife population are evaluated for years one, twenty-five, and one hundred in terms of the following:

Wildlife Category	Estimate Units
Habitat	Cover type acreages
Fish (several specific species)	Population levels by species
Deer	Deer use days
Rare and Endangered Species	Status, habitat areas
Waterfowl and Shorebirds	Qualitative expression of increase or decrease for group as a whole
Upland Game	Qualitative expression of increase or decrease in particular species.
Furbearers	Qualitative expression of increase or decrease in particular species.
Other Birds	Qualitative expressions, some specific to species.
Other Mammals	Qualitative expressions, for selected species.
Reptiles and Amphibians	Qualitative expressions for reptiles as a whole and amphibians as a whole.

Future without the project:

Estimated wildlife conditions largely take into account urbanization pressures, including: conversion of wooded areas to pasture, firewood cutting, timber operations, construction, recreation, germicides, and controlled burning.

Future with the project:

Estimates take into account the same factors as for without conditions as well as those associated with the project, including: inundation temporary construction, flood frequency pool, recreation impact, and impacts within the view shed.

FREEPORT HARBOR PROJECT

(Galveston District)

Type/Purpose: Navigation, i.e., enlargement and realignment of main channels and basins to accommodate present and prospective traffic.

General Setting: Commercial port in urban area; some natural areas in coastal salt marsh, higher marsh, and prairie.

Projection Categories: Because of project circumstances, projection confined to with-project habitat values at target-year intervals at the five sites that would be impacted (disposed on) by the project.

Target Years: Existing, 0, 10, 20, 30, 40, 50.

Study Period: Expected life of the project, 50 years.

Special Considerations: Since the area is well developed, the land use changes that would occur would be from one type of nonhabitat to another. The intent of the environmental analysis was to estimate the change in habitat value that would occur on proposed disposal areas and to estimate the acreage that should be acquired to mitigate for those expected losses. Because disposal areas were the object of evaluation, no change in acreage was anticipated, only change in condition and therefore in habitat quality.

Considering the nature of the project and the area in which it would be constructed, land acquisition and management were the most applicable mitigation measures. For this study an analysis was developed to indicate how many acres of tidal wetland would be required to compensate for the habitat losses in the various habitat types of the disposal areas.

Habitat Evaluation and Projections

The evaluation is based generally on the FWS' HEP procedures. The habitat type of each of the five proposed disposal areas was determined and wildlife groups were selected as evaluation elements to be rated in each of the areas.

Wildlife Groups

Non-aquatic birds
Marsh and wading birds
Waterfowl
Small to medium-sized mammals
Reptiles and amphibians

Habitat Types

Coastal prairie and high marsh
Coastal prairie and barrow area
Existing disposal area
Coastal prairie

Existing Conditions: For the analysis, each disposal area and the proposed compensation area were evaluated as to their existing condition. To do this, the value of each sampling site to each wildlife group was rated on a scale from 1 to 10 and then the value of each area was calculated. The criteria for the 1 to 10 rating scale took into consideration a judgemental recognition of wildlife abundance:

Rating	Habitat Quality	Description
0	Useless	Habitat will not support most forms of life
1-2	Poor	Poor habitat, unsuitable for most desirable species, organisms uncommon
3-4	Fair	Marginal quality, organisms uncommon
5-6	Average	Moderate to variable quality, organisms fairly common or fluctuating in abundance
7-8	Good	Good quality, food and cover for many species, organisms common
9-10	Excellent	Very high quality habitat, excellent food and cover for most species, organisms abundant and diverse.

Projections: With-project conditions that would be expected to occur in the disposal areas over the life of the project were described. Based on these descriptions and using the same scale and calculation methodology as for existing conditions, the quality condition of each disposal area at each target year was determined. Projections and evaluation of future conditions at the proposed compensation area were not done.

The disposal area conditions projected to result from project implementation are as follows:

Year	Condition
0	Newly created disposal area being filled with standing water and unconsolidated sediments.
10-30	Disposal area in use. Conditions will remain the same throughout this period and are essentially the same as during the initial project year.
40	Disposal area nearly filled and relatively barren. Quality of habitat expected to be the worst of any time during the project life.
50	Disposal area abandoned for approximately 7 years. Early successional stages of vegetation and wildlife populations have been established, but the habitat is suppressed in comparison to original conditions.

Impacts

The impact of disposal was calculated as the annualized change in habitat units from existing conditions to the end of the 50-year period of analysis. The without project condition was considered to be the same as the existing conditions.

Out-of-Kind Compensation Requirement

For each disposal area, the number of acres required to offset habitat losses in that area were calculated as:

$$\text{Compensation (in-kind)} = \frac{\text{Annualized losses or gains}}{\text{Management Potential Unit Value}}$$

This calculation was performed for each of the five disposal areas; their summation indicated the total in-kind compensation need for the project.

However, since mitigation was to be by compensation with tidal wetlands, i.e., out-of-kind, it was necessary to determine how much tidal wetland would be needed to replace the losses of the various habitat types in the disposal areas. This was done by applying the following assumption to each disposal area: that the ratio of out-of-kind compensation to in-kind compensation would be directly proportional to the ratio of the existing habitat value at the disposal area to the management potential unit value at the compensation area.

$$\frac{\text{Out-of-kind Comp Req.}}{\text{In-kind Comp Req.}} = \frac{\text{Existing habitat value, disposal area}}{\text{Management Potential Unit Value, comp area}}$$

Thus, the out-of-kind compensation required for losses at a given disposal area was calculated as:

$$\frac{\text{Existing habitat value, disposal area X in-kind comp req}}{\text{Management Potential Unit Value, compensation area}} = \text{Out-of-Kind Comp. Req.}$$

This calculation was performed for each of the five disposal areas; their summation indicated the total out-of-kind compensation need for the project. In the Freeport Harbor Study, the out-of-kind compensation acreage required was approximately one-half that for in-kind compensation.

ROWLETT CREEK (Fort Worth District)

Type/purpose: Expanded floodplain information. Evaluation of implications of alternative future land use conditions on each of the existing habitat categories and their associated biota.

General setting: Rolling topography, area largely rural. Predominantly pasture and farmland with woodlands along the streams.

Projection categories:

Land Use	Land Cover: Habitat Type
Urban (16 classes)	Residential, Urban and Parks and Open Space
residential	Cropland
commercial	Grassland
institutional	Confined feeding
industrial	Forest land
transportation	Water bodies
communications	Barren land and inactive strip mines
public utilities	Fence rows
parks/open space	Wetlands
vacant urban	Ecotones

Rural (6 classes)
- cropland
- grassland
- confined feeding
- forest
- water body
- barren land

Target years: Five land use conditions analyzed that are representative of a range of development conditions.

Condition	% Urban	% Rural
Historic, 1964	6	94
Existing (base), 1976	20	80
Future, near-term (c. 1986)	35	65
Future, most probable total development	70	30
Future, maximum probable total development	94	6

Study area: the entire watershed.

Study period: not defined in time, study evaluation futures depicting the most probable and the maximum probable development that could occur.

Projections (given)

Conceptual futures are based on information from local and regional planners and from published plans for some of the cities. Futures are analyzed as given in terms of conditions reflecting implementation of various flood plain regulatory policies. Analytical procedures enable determination of futures impacts (acreage loss or gain of habitat types) and resource management impacts.

Impacts

Procedure to assess impacts incorporates relatively new data management and analytical techniques. The watershed is subdivided into rectangular 1.1-acre grid cells. The data bank for analysis is developed by assigning values to each cell to define physical parameters (e.g. land use, habitat, elevation, soil, location, etc.) The procedure could be described as a computerized version of the manual technique of graphic overlaying of geographic data.

Future land use conditions

Impacts of future conditions are considered as the evaluation of the projected development futures against the existing environmental habitat conditions. Net impacts are given in terms of acreages of each habitat type. Impacts are determined essentially by developing an environmental inventory and then evaluating the inventory in terms of each future. Briefly, the steps in the procedure are:

1. Map existing habitat types
2. List biota associated with each type
3. Computer manipulation of data bank to interact existing habitat with alternative future land use data to determine habitat acreage losses and gains
4. Evaluate implications of future land use changes on habitats and biota.

Resource management evaluations

The computerized data bank enables spatially-related environmental analyses. Resource problems that can be handled include: 1) determination of land use change; 2) identification of areas of potential impact resulting from a particular activity; and 3) identification of areas most attractive for a particular activity. Identification of these areas permits production of a resource plan suited to regional development needs.

Four major types of analysis are used:

1) Coincident tabulation-
   used to catalog land use conditions and determine land use change (in acres) between two conditions
2) Impact assessment-
   used to determine areas with the greatest potential impact for a particular activity
3) Locational attractiveness-
   used to spatially locate areas that are most attractive for a particular activity.
4) Distance determination-
   used to determine the minimum distance of each grid cell from a cell containing a variable of interest.

Treatment of Wildlife

Wildlife is handled in terms of habitat acreage loss or gain. Since wildlife and vegetation associated with each habitat type are listed, then it is known what species would be affected by a change in acreage. It is also known what areas are prime habitat and where change in acreage would be most environmentally critical.

WALNUT AND WILLIAMSON CREEKS
(Fort Worth District)

Type/purpose: Expanded floodplain information. Development of basic information on flood hazards, general information on flood damage potential, and information on the impacts of land use changes on the environment.

General setting: Located near Austin, Texas, both study areas undergoing dynamic growth from primarily rural to highly urbanized.

Projection categories:

Habitat Cover Types

- Urban habitat
- Cropland
- Shrub - Brushland
- Pecan - Elm
- Live Oak
- Live Oak - Ashe Juniper
- Aquatic Edge
  - Steams and creeks
  - Lakes and ponds
  - Wetlands
- Herbaceous Range
- Elm - Hackberry
- Mesquite
- Post Oak - Live Oak
- Ashe Juniper
- Mesquite - Juniper
- Barren Land

Land Uses

- Low density residential
- Medium density
- High density residential
- Multi-family residential
- Mobile home parks
- Strip commercial
- Shopping centers
- Institutional
- Industrial
- Transportation and related
- Industrial and commercial complexes
- Parks and open-space
- Public use
- Undeveloped urban land
- Cropland and related
- Pasture and related
- Forest land
- Water bodies
- Barren/transitional

Habitat Values (modified HEP analysis) for the following 10 species:

- Whitetail deer
- Red-bellied woodpecker
- Gulf Coast toad
- Raccoon
- Striped skunk
- Fox squirrel
- Mowing dove
- Red-tailed hawk
- Carolina wren
- Green anole

Target years: Five land use conditions analyzed that are representative of a range of development conditions.

Condition, Williamson Creek	% Urban	% Rural
Historic, 1958	10	90
Existing (base), 1979	36	64
Three futures, c. 1995 -		
No. 1, least urbanized	58	42
No. 2, more urbanized	65	35
No. 3, most urbanized	73	27

Conditions, Walnut Creek	% Urban	% Rural
Historic	9	91
Existing (base), 1979	30	70
Three futures, c. 1995 -		
No. 1, more urbanized	66	33
No. 2, least urbanized	61	39
No. 3, most urbanized	86	14

Study Area: Entire watershed of Walnut Creek and Williamson Creek.

Study Period: Fifteen years.

Projections (given)

Alternative future land use conditions were defined by the City of Austin as year 1995 approximations. The futures depict conceptual patterns and are general; they cover a broad range of possible futures so as to establish a basis for generalization of other futures. The schemes are not master plans for growth or zoning but do show generalized growth consistent with recent development and population projections.

Impacts

In order to systematically evaluate the effects of land use changes over time, data is managed and analyzed through use of the Spatial Analysis Methodology (SAM). The approach involves subdividing each watershed into a rectangular 1.15-acre grid cell network and assigning values to each cell which defined physical parameters.* The major data variables include:

- existing land use
- soil type
- existing habitat
- land surface slope
- unique environmental sites
- future habitat(s)
- habitat suitability indices (HEP)
- distance to urban activities
- topographic elevation
- historic land use
- hydrologic subbasin
- future land use(s)
- flood plains
- damages reaches

* In addition to basin-wide data gridded in 1.15-acre cells, the floodplain area along each stream is defined in variables gridded in 0.29-acre cells.

Each of the five (existing, historical, and three futures) land use conditions are analyzed in terms of their implications on: single event and average annual flood damage, flood flows, flood depths, flood plain delineations, habitat changes, and stormwater pollutant loadings. Also, four flood plain regulation policies are considered as part of the analysis of flood damage potential.

Treatment of Wildlife

Wildlife are treated in terms of their habitat and habitat is evaluated in terms of habitat value and how that value may be altered by land use change. Habitat values are measured relative to the values for ten selected species. The species groups selected were considered to be as representative as possible of the total wildlife community.

The analysis approach for evaluating the implications of future land use change on wildlife habitats and their associated communites involves a linking between the U.S. Fish and Wildlife Service's HEP and the Corps' SAM. The hybrid procedure enables:

1. Determination of net habitat value gains or losses with any future urbanization scenario.

2. Identification of habitat types to which value gains or losses will occur.

3. Identification of species and species associations which will benefit or be adversely affected by future development.

4. Quantification of habitat value gains or losses by species or by habitat units.

The key modification to HEP is the inclusion of the parameter distance to urban activities as being a factor in habitat quality. The assumption being that the nearer a given habitat type is to an area influenced by man's activities, the less sutiable the habitat for most wildlife. To apply this concept, the HSI values are discounted as a function of the distance of a given habitat from urban activities. The amount of discount is determined by professional judgement and is only applied to the HSI values of species that are negatively influenced by man's activities. The urban distance zones by which HSI values are discounted are as follows:

primary habitat;	> 400 ft from urban habitat (HSI values not discounted)
transition impact zone;	$\leq$ 400 ft and $\leq$ 200 ft from urban habitat
immediate impact zone;	< 200 ft from urban habitat

It is assumed that the HSI value for areas of primary habitat (> 400 ft. from urban areas) would not be influenced by man's activities.

APPENDIX B

EXAMPLES FROM THE CASE STUDIES
INDICATING HOW DIFFERENT PLANNING PROBLEMS
HAVE BEEN APPROACHED

PROCEDURAL DETAILS OF LAND USE PROJECTIONS
AT BIG BLUE AND LOUISVILLE LAKES*

Basic Assumptions

a. Domestic and export demand for food and fiber will continue to increase.

b. Big Blue and Louisville Lake project lands will be used more intensively for agricultural production in the future.

c. Agricultural land prices will continue to increase.

d. Trends toward larger-farming units will continue.

Projection Procedure

Land use projections, although speculative, reflect the basic assumptions listed above and the subjective judgement of the projector. The following details the projection process used.

a. Project acquisition lines were delineated on base maps (i.e. aerial photographs and/or topographic maps). A breakdown of existing land use was obtained by habitat type from Louisville District Biologist.

b. Base maps were divided into subareas of about 1200 acres each to facilitate data collection, organization, measurement, etc.

c. Population data were reviewed (i.e. historical and projected county and OBERS area). However, no direct application of this data was made in the projection process.

d. Several days were spent in the project area by the projector.

1. Local county USDA, Soil Conservation Service (SCS) offices were visited. These offices offered some insight into local land use trends and provided detailed soil capability-crop yield potential and identification of drainage problems.

Collection of soils-crop yields and drainage data would have been greatly simplified had published soil surveys been available for the counties involved. Since these

*Writeup provided by the Louisville District.

surveys were not available at the time in either the Big Blue or Louisville project areas, the following method was used. It should be noted that without the projector's former employment with SCS and Knowledge of their soil mapping and classification system, collection and interpretation of needed data would have been very confusing, time consuming, and disruptive to SCS offices. Individual soi` mapping sheets were cross-referenced to project base maps and soil mapping symbols recorded thereon. Soil symbol-capability class-slope-draiage interpretation sheets were obtained for each soil series in the project area.

2. Onsite observations were made in the project areas (both within and outside the acquisition boundary). Based on observation of land use, discussion with SCS officials, previous review of property records during tax impact studies, and economic surveys of downstream project-benefitted areas, it is expected that agricultural production, the dominant land use at present, will continue to be dominant in the future in both the Big Blue and the Louisville project areas. Further, gradual conversion of woodland to cropland, fewer, but larger farms, and larger fields are trends expected to continue in the future.

3. Areas within the subareas mentioned previously, were field checked in considerable detail. Particular note was made as to location of wooded areas relative to crop fields, shape of and access to wooded areas, and evidence of recent land clearing. Using soil data, described previously, bottomland and upland wooded areas considered most likely to be converted to agricultural use were noted. Bottomland woods will most likely be converted to corn and soybeans, while uplands will be converted to hay and pasture. Dominant land conversion factors considered were soils, drainage, flooding, and accessibility of bottomland woods, and slope and location of upland woods. Land use attitudes of current landowners were not considered. Ownership patterns and attitudes will no doubt change during the projection period and would be impossible to project. Projected land uses reflect economically rational uses for agricultural production within the basic constraints of soil capability as defined by the SCS.

4. Trends toward larger farms, fields, and farm implements are expected to result in the loss of fencerow and ditch bank habitat. Areas adjacent to large crop fields that are considered most likely to be lost were noted.

5. Trends toward more and larger ponds will likely result in slight lossses of hay and pastureland. Programs are admininstered by USDA support in this trend.

6. Economic pressures are expected to result in decreases of old fields. This category is made up largely of idle crop and pasturelands that are reverting to weeds and bushes. Some of these lands can be converted to their former use at nominal cost. Lands most likely to be converted were noted on base maps, based on observation and reference to soil capability data.

7. Intensification of bottomland crop production on lands previously cropped and those expected to be converted from woodlands will result in improvement of drainage on some of these lands. Programs administered by USDA provide financial and technical assistance to landowners to improve agricultural drainage. By reference to the soils capability and to the experience of the land use projector, areas characterized as wetland that are likely to be drained were noted.

8. Present and expected future "without project" land uses are similar in the Big Blue and Louisville project areas, except for residential development. While sparse residential development exists at the Louisville project and little future increase is expected, considerably greater residential development exists at Big Blue, and significant future increases are expected. New residential development has recently occurred in the Big Blue project area, primarily in upland wooded areas. Several new houses are under construction. The project area is within commuting distance of the metropolitan area of Indianapolis. It is anticipated that residential development will continue, especially in wooded uplands adjacent to established roads.

9. No significant changes were considered in land uses now occupied by roads, roadsides, streams, and streamsides.

Land Use Projections

As mentioned previously, areas judged to have land use change potential were identified from onsite observation and noted on project base maps. Further, these land areas are those expected to be changed by the end of the projection period (i.e. 100 years beyond the project base year). Procedural detail of these projections are as follows:

a. Land use changes denoted on project maps within each of the subareas were measured and gains and losses were subtracted or added to current land use habitat acreages. The derived acreages were assumed to reflect year 2085 land use.

b. Current and year 2085 land use acreages were plotted on cross-section paper. These two points were connected by a straight line to derive intermediate year projections. This

simple procedure is considered to be as valid as any other, in view of the uncertain nature of land use projections.

c. Land use acreages were tabulated from the plotted curves and adjusted slightly so that project total acreage remains constant.

PROCEDURE FOR
ESTIMATION OF LOSS OF WILDLIFE HABITAT
DUE TO RESERVOIR-INDUCED DEVELOPMENT
AT UNION LAKE

An objective estimate of habitat loss due to shoreline development was derived through a three-phase procedure.

Phase I: Simulate residential development

Through a randomized procedure, units of development are assigned to sites on the basis of supply of vacant land available and its relative attractiveness for recreational and permanent residential use.

Assumptions. There are three basic assumptions to the procedure:

a) That there is predictability in human behavior. Knowing development behavior and factors at other reservoirs, it was assumed that development induced at Union Lake would be similar in magnitude and density to that at other reservoirs.

b) That all land in the study area (within 300 ft. of take-line) would be available for development.

c) That sites would develop in order of their relative attractiveness (i.e. presence of location factors).

Steps.

1. Location factors were defined and mapped separately on acetate overlays. The study selected 5 factors based on those that were significant in the development at a similar reservoir. Local real estate developers reviewed the validity of the factors. The factors were:

i) road distance to metropolitan area,
ii) peninsular location,
iii) aerial distance to shoreline,
iv) availability of public road, and
v) lack of ground cover.

2. Attractiveness of area was determined by composite of overlays; thus, sites with 5 factors overlapping would develop first, then those with 4, etc.

3. Determined amount of development. Recreation analysis had shown that visitation at Union Lake would be high. A linear regression of annual visitation and number of shoreline dwellings was run for a set of reservoirs having high visitation (500,000). Based on the anticipated visitation at Union Lake and this regression, the number of shoreline dwellings to be expected was estimated at the 95% confidence level.

4. Determined density of development. Based on development densities at similar reservoirs, it was assumed that the average lot size would be .25 acres; and allowing for development needs (roads etc.) the size was increased to .30 acres.

5. Assigned site development by random allocation until the amount of development predicted (estimated number of dwelling units) was achieved.

Phase II. Estimate future wildlife habitat conditions without the reservoir

1. Determine amount of normative development. This was accomplished by projecting the normal growth rate of the study area (based on existing conditions and trends) and projecting the number of dwelling units that would be expected in the area (projected population for Year 2020 divided by 3.2 persons per dwelling).

2. Assign site development for the projected number of dwellings. Because there was insufficient information on the study area's normative growth location factors, spatial allocation was done as for with-the-project. This was based on the intuitive assumptions that sites attracting normative growth would have similar location factors and habitat quality as the sites of first magnitude attractiveness for reservoir-induced development. A density value of one dwelling per half-acre was used. This is the average size of a rural nonfarm lot in the county.

Phase III. Estimate effect on wildlife habitat

1. Estimate the amount of habitat (HU) displaced by reservoir-induced development by subtracting the normative growth from the with-project development.

2. Estimate the impact on wildlife habitat through onsite inspection. Consideration was given to the sites'* present quality and the reservoir-induced development simulated for each site. This assumes that the quality of habitat displaced by normative growth would be similar to that displaced by reservoir-induced level.

*Sites refers to the attractiveness areas delineated by composite overlays of location factors in Phase I.

PROCEDURES FOR PROJECTION OF FUTURE WITH AND WITHOUT PROJECT LAND USE AND WILDLIFE CONDITIONS FOR MARYSVILLE LAKE PROJECT

Initial assumption: although conditions are described at 25-year intervals, it is assumed that the second 50 years is constant to conditions at the end of the first 50. This assumption is made because of uncertainties in making projections for the second 50 years.

I. Land Use

A. Describe present land use conditions (Yuba County)

1. Geologic description including shear zone, groundwater aquifers, gold dredge tailings

2. Geographic description including characteristics of major regional topographic areas

3. Soils description including delineation and characterization of the major associations

4. Land use description including location, acreage, and percent makeup of six land use categories as given by the 1968 Yuba County general plan

5. Population data taken from 1970 census and compared against 1960 census to determine changes and trends in density and urban vs. rural.

6. Public utilities (including transportation, railroads, airport) and commercial and industrial development located and described.

7. Archaeological and historical sites located and described.

B. Describe future land use conditions without the project

1. For this project, assume that future land use at end of first 25 years (1990) will be in accordance with that for 1985 as described in the Yuba County General Plan.

2. The 50-year projection of land use is based on population trend projections. Population projections are available for the first 25 years (to 2015) and those trends are continued in order to project the 50-year population level. Then, determine land use

projections by assuming that county population changes will be the driver in land use changes. In developing land use projections, consideration is given to regional population changes and what impact there may be on recreation use, vacation home development, agriculture, etc. in the area.

C. Describe future land use with the project

1. For this project, assume that the land use will generally be similar to that described for the without project condition. The major differences to be expected relate to Federal land acquisition for the project, construction activities, and lake-recreation based activities.

2. Overall, assume that this is the case, the project will have no impact on long-range population trends and there will be no major departure from without project conditions; the difference with the project would be <u>where</u> the changes would occur and with <u>what</u> intensity.

II. Water Use

A. Describe present use including water rights, groundwater users, surface water users, and volumes used.

B. Describe future use as to present, medium, and full use. For this study, no projections were available for future water needs. A most probable future condition of water use was developed through conferment of USFWS, the California Dept. of Fish and Game, and the Corps.

III. Plant Communities

A. Describe present vegetation

1. Describe climate, historical influences, and areal percentage breakdown of cover types for the county.

2. Describe characteristics of plant communities within the project area and general description of communities outside the area.

3. List and locate rare and endangered plants as to their known and possible occurrence.

B. Describe future plant communities without the project. The description is based on anticipated changes in successional stages (stability). land use, intensity of recreational use, and water use.

C. Describe future plant communities with the project. In addition to considering changes in successional stage, land use, recreational use and water use, anticipate:

1. losses due to construction and inundation

2. project-induced changes outside of the gross pool and in the county

3. changes expected to occur through time in the project area such as vegetative recolonization on construction-damaged areas and increased stress from intensity of recreational use

In describing future with project plant communities, assume that losses to agricultural and developmental land uses will be similar to those anticipated for without the project but they will be somewhat greater, e.g. recreational and residential growth in the vicinity of the project will be greater than it would otherwise be.

IV. Wildlife resources

A. Describe present wildlife resources for both within and outside of the project area by resource category (deer, waterfowl, etc.)

1. Include where applicable the distribution, abundance, composition, range, seasonal range, harvest data, hunting or fishing access, habitat use, habitat quality, and regional perspective. For example, for birds this includes estimated density and diversity by plant community type; for deer, population data was lacking and pellet counts were used to estimate populations for various habitats at different seasons and to estimate the number of use-days.

2. List and locate rare and endangered species as to known and possible occurrence

B. Describe future wildlife resources without the project

1. Habitat areal (plant community) changes are identifiable from previously developed information (anticipated land use changes and successional changes)

2. Based on habitat changes, resource population levels are estimated for both within and outside of the project area. For some species population levels are projected by using workable estimates; e.g. for deer estimates of 7.5% reduction by 25 years and 15 % by 50 years are used. For other species the best possible estimate can only be given as a general description of population trends: e.g., steady decline or slight gradual increase. These general trends are interpretable from habitat areal changes and anticipated degree of support.

C. Describe future wildlife resources with the project. Future is basically the same as for without the project with the major exception of habitat acres and population losses in the gross pool area. Indirect losses are descibed in a more general way, some of these will require more study to estimate.

SCENARIOS DEVELOPED FOR PROJECTING
FUTURE LAND USES IN THE
IMMEDIATE PROJECT AREA, COTTONWOOD CREEK BASIN*

Minimum Growth Scenario

Assumptions:

(1) Continued agricultural zoning will be desired by most property owners and county officials. County policy will be to encourage future growth in or near existing urban areas to minimize cost of county services, preserve environmental quality, etc.

(2) Septic tank suitability, ground water availability, topography, and road access will restrict areas of development.

(3) Developments will be primarily 5- to 10-acre rural residential parcels. Developments will not be dense enough to support significant commercial or urban-type services (gas stations, garbage collection, sewers, water, shopping centers, banks, etc.).

(4) Future shortage of gasoline and electricity and forced conservation measures plus high construction costs will severely limit demand for rural-residential/second-home property in the immediate project area.

(5) Minimal public use facilities and low visitation at the project lakes.

Growth Projections and Impacts:

(1) Project will not induce net population growth in Cottonwood Creek Basin or surrounding areas. However, populations will be distributed differently due to the presence of the lakes.

(2) Roughly, the same development will occur in the immediate project area with or without the project, so there will be little change in total acreages under each land use category.

(3) Developments, that otherwise would have taken place on the lands acquired for the project, will occur on lands adjacent to the lakes, at a slightly higher density. Developments both with and without the project will occur primarily on oak woodlands presently used for cattle grazing.

(4) Without project: 1,000 acres rural-residential; with project: 1,000 acres rural-residential.

Assumptions:

(1) Continued agricultural zoning will be desired by some property owners, but counties will allow substantial amounts of agricultural land to be rezoned to permit 5-acre minimum parcel size development. County policy will be to control location and amount of satellite developments so that need for expansion of county services will be minimized.

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* From U.S. Army Engineer District, Sacramento (1979).

(2) Septic tank suitability, ground water availability, topography, and road access will restrict areas of development.

(3) Developments will be primarily 5- to 10-acre rural-residential parcels. Development will be dense enough to support some commercial development (stores, gas stations, etc.) near reservoirs, but not dense enough to support most urban-type services (garbage collection, sewers, water, shopping centers, banks, etc.)

(4) Future shortage of gasoline and electricity will drive up prices, resulting in voluntary conservation, but no mandatory conservation measures will be enacted. Construction prices will be high, but will not be a serious constraint on recreation-home development.

(5) Medium-level recreation development and moderate recreation use will occur at the project lakes.

Growth Projections and Impacts:

(1) Project will result in moderate net increase in permanent plus part-time residents of immediate project area.

(2) Developments will occur primarily in the "viewshed" on north and east sides of Dutch Gulch Lake and at several locations around Tehama. Development will occur first in areas where road access is good and topography is relatively flat. As more desirable locations are taken, development will gradually spread into areas where development costs are higher.

(3) There will be a net increase (due to the project) of about 3,000 rural-residential acres in primarily 5- to 10-acre parcels over the next 100 years, and corresponding decrease in oak woodlands used for cattle grazing.

(4) Without project: 2,000 acres rural-residential; with project: 5,000 acres rural-residential.

(5) A moderate amount of wildlife habitat in the immediate project area would be degraded or destroyed. However, state and local laws (CEQA, etc.) might require developers to mitigate damages.

Maximum Growth Scenario

Assumptions:

(1) Counties will allow unlimited amount of agricultural land to be rezoned to permit 1/4-acre minimum parcel size, multiple-family dwellings, and commercial development. County policies will favor rural-residential development and extension of urban services to large satellite developments.

(2) Livestock grazing will become very unprofitable due to high operating expenses, forcing owners to sell large land holdings.

(3) Septic tank suitability, ground water availability, topography, and road access will restrict areas of development.

(4) Developments will vary from 1/4- to 10-acre parcels, depending on topography and quality of scenic vistas. On large relatively flat areas with a good lake view, a few subdivisions of 1/4- to 1-acre lots, and perhaps apartments or condominiums, with sewer and water service will develop. The high density of development around the lakes will support considerable commercial development, including laundromats, small shopping centers, gas stations, a bank, etc. County roads will be upgraded to handle substantial traffic increases.

(5) Due to technological breakthrough on energy, future shortages of fuel for automobiles and electricity will be minimal. Therefore, although prices for fuel (and home construction) will be higher, the demand for second-home and rural-residential development will continue to be high.

(6) Optimum-level recreation development and high recreation use will occur at the project lakes.

Growth Projection and Impacts:

(1) Project will result in major net increase in permanent plus part-time residents in the immediate project area.

(2) Developments will occur in roughly same areas as Scenario #2, but at a greater density.

(3) There will be a gradual net increase (due to the project) of about 6,500 rural-residential and urban acres, with a corresponding decrease in oak woodlands used for cattle grazing.

(4) Without project: 3,000 acres rural-residential; with project: 9,500 acres rural-residential and urban.

(5) A significant amount of wildlife habitat would be degraded in the project viewshed. However, state and local laws (CEQA, etc.) might require developers to mitigate losses.

INTEGRATION OF THE HEP AND SPATIAL ANALYSIS METHODOLOGIES ON THE WALNUT AND WILLIAMSON CREEKS STUDY*

The Corps of Engineers, working with the Fish and Wildlife Service, has interfaced GIS technology with the Habitat Evaluation Procedures (HEP) using the HEC-SAM system. HEP is a species oriented system which uses cover types as the basis for the analysis. The interface developed was first used in the Walnut-Williamson study by the Ft. Worth District and there are currently several new applications.

The basis for comparision in HEP is the Habitat Unit, which is calculated by multiplying the quality of habitat by the amount of habitat available for each species. By using the interface to a GIS system, an analyst can visualize the distribution of this abstract number. In addition, using a GIS allows for easy application of modifiers such as distance to human disturbance. Figure 1, 1979 Habitat Suitability Index for red-tailed hawk, shows the quality of the habitat for that species for the Walnut Creek Watershed. Figure 2 is a similar display of the spatial distribution of the quality of the habitat for an alternative future land use condition. By comparing the two figures in conjunction with the habitat unit change calculation, the analyst can visualize the spatial consequences as well as the bottom line in lost habitat.

HEP is an accounting system which is based on multiple evaluation species. Whereas Figures 1 and 2 show the distribution of quality for a single species, Figures 3 and 4 show the combined quality for all species used in the analysis. Figure 3, 1979 RVI's are unweighted, shows the existing condition with each species' relative value index (RVI) having equal (unweighted) weighting. Figure 4 shows the same condition with each species receiving a relative weighting. In this example white-tailed deer, red-tailed hawk, red-bellied woodpecker and Carolina wren were the species which received higher relative weights compared to the other six species in the analysis. It should be obvious that even though the total number of Habitat Units may be the same in both figures, wildlife managers would focus their activities in different areas depending on which RVI weights were used to capture the ecological issues in a study boundary.

The Corps of Engineers and the Fish and Wildlife Service are continuing on using a GIS data base to do cell by cell species modeling. This will allow the analyst to capture differences in habitat quality within cover types as well as between cover types. The cell by cell modeling includes habitat composition and interspersion factors within a species home range as well as distance modifiers, such as distance to human generated disturbances and/or missing species life requisites.

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*Material extracted from Webb (1981), pp. 344-348.

Figure I. 1979 Habitat Suitability Index for red-tailed hawk.

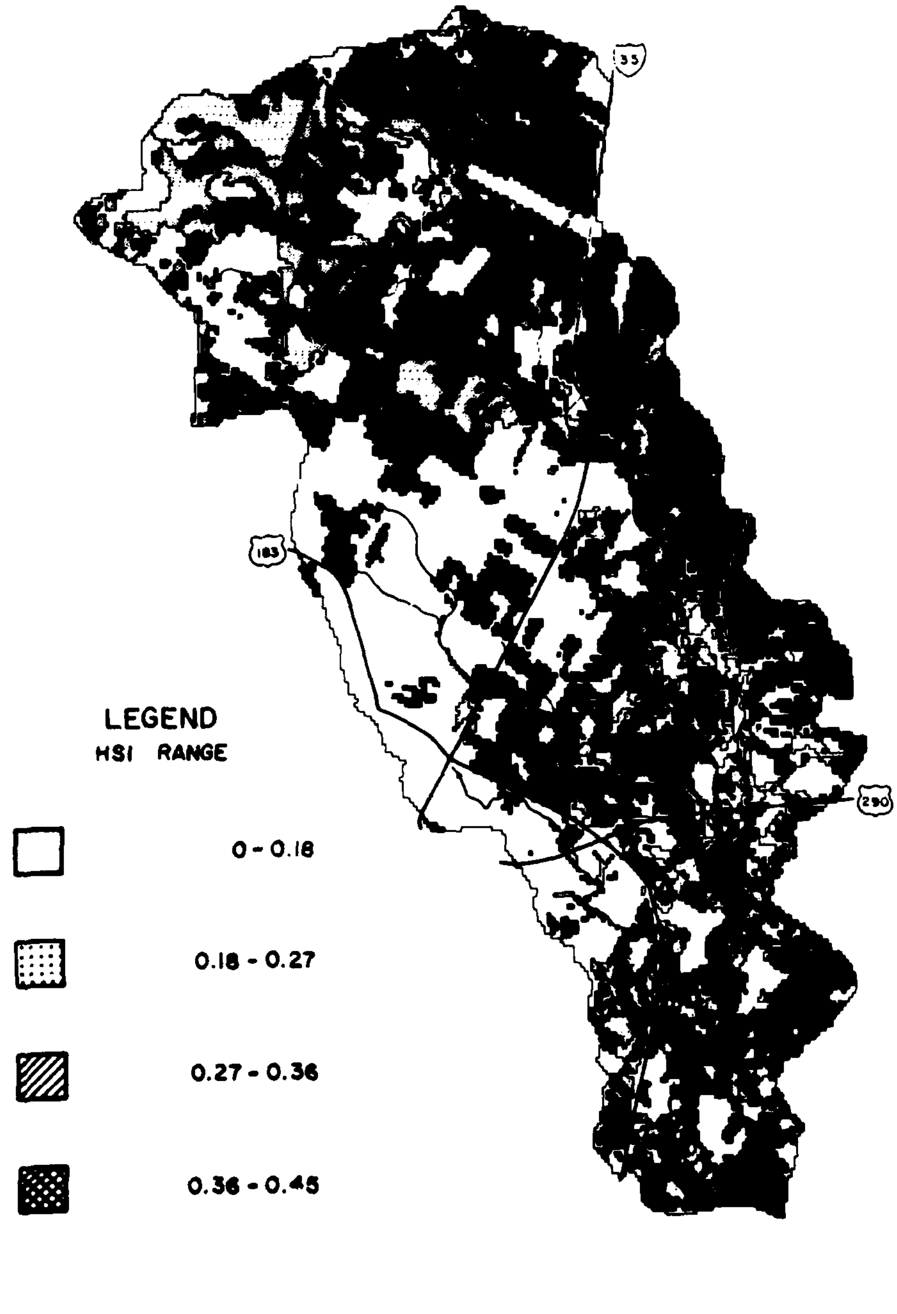


Figure 2. Future 3 Habitat Suitability Index for red-tailed hawk.

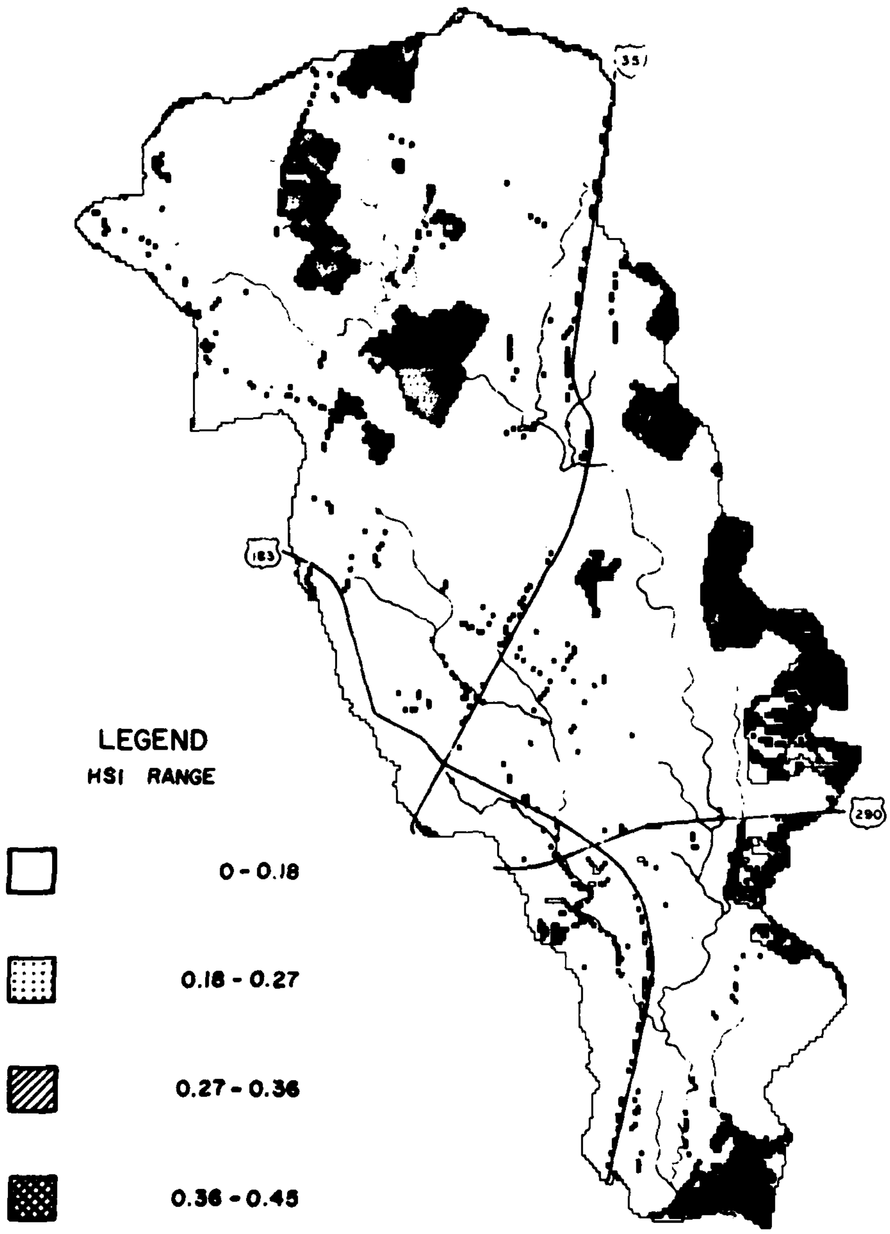


Figure 3. 1979 RVI's are unweighted.

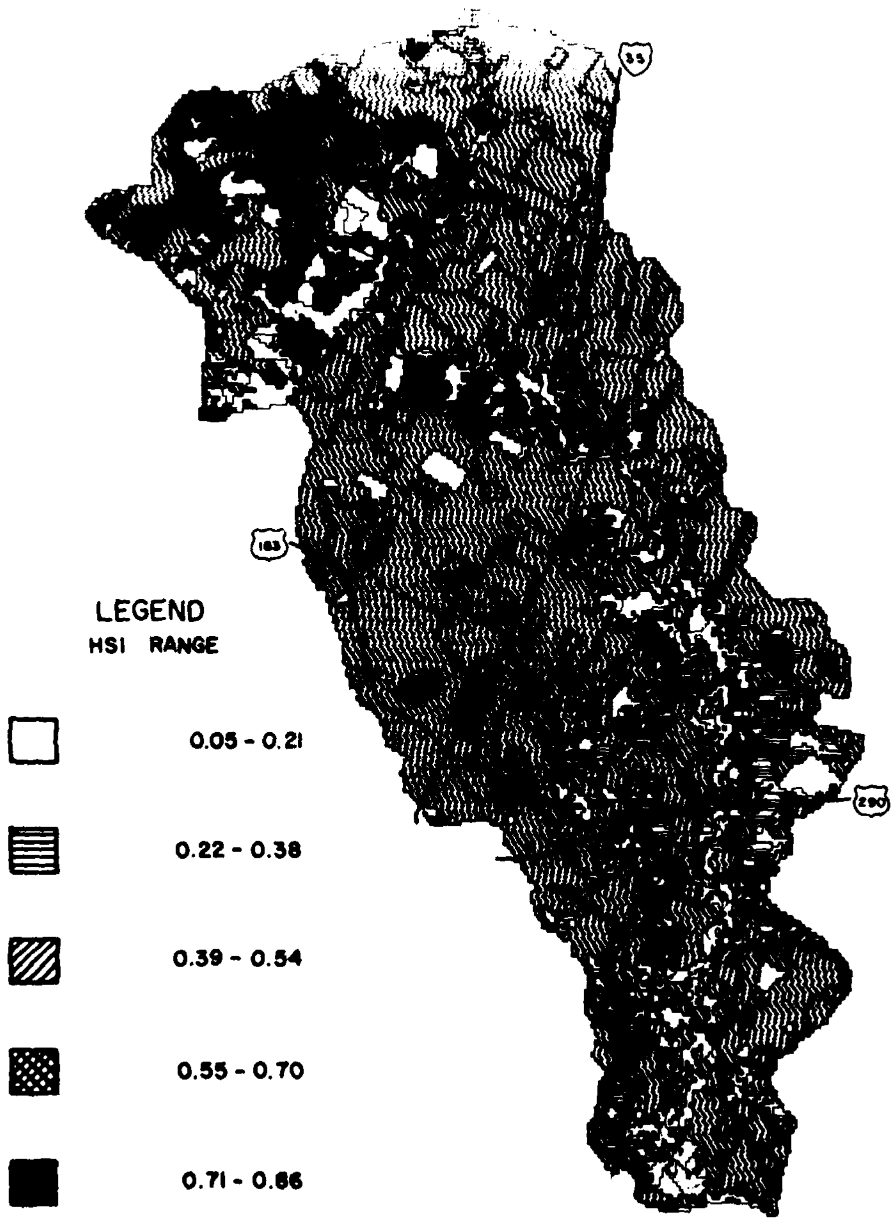
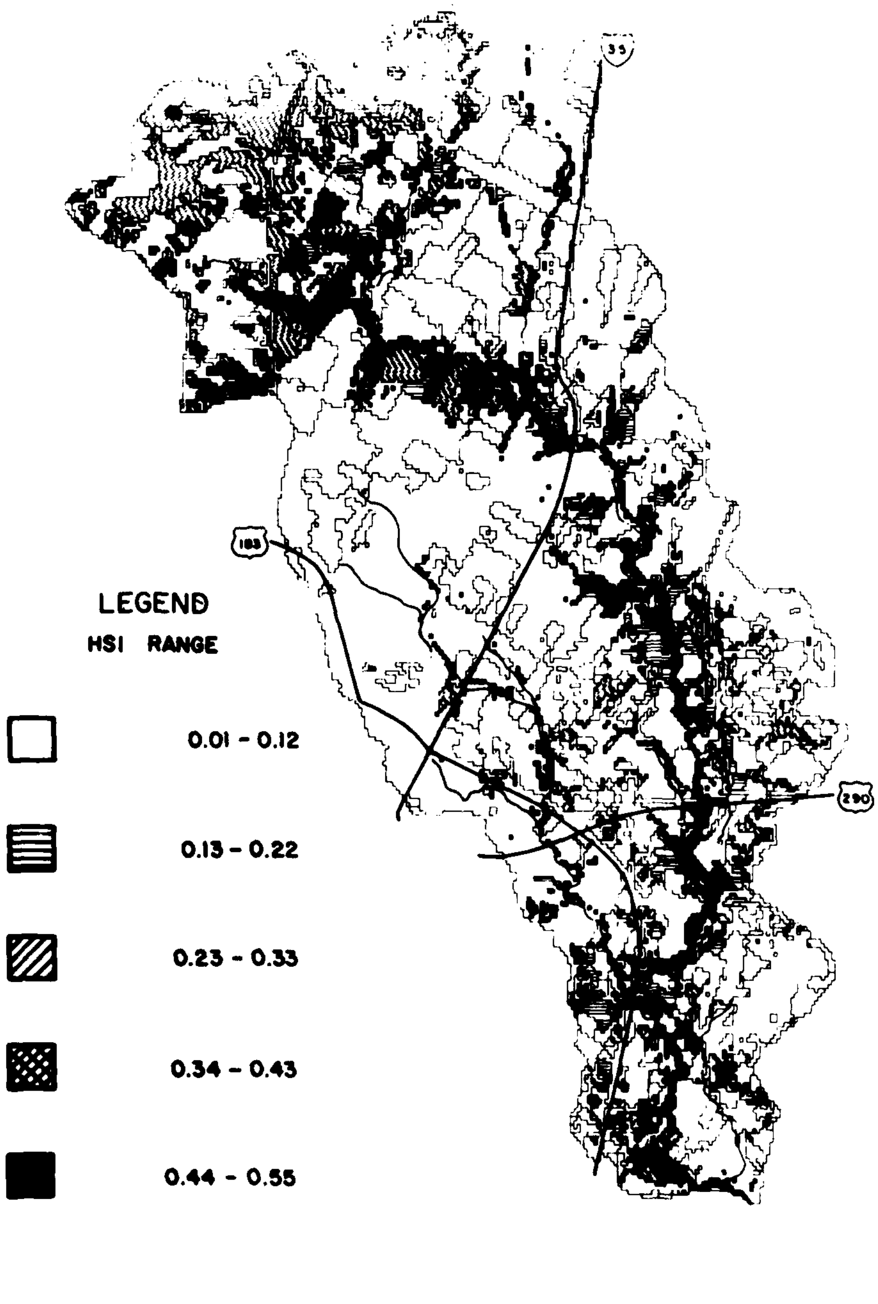


Figure 4. 1979 RVI's are weighted.

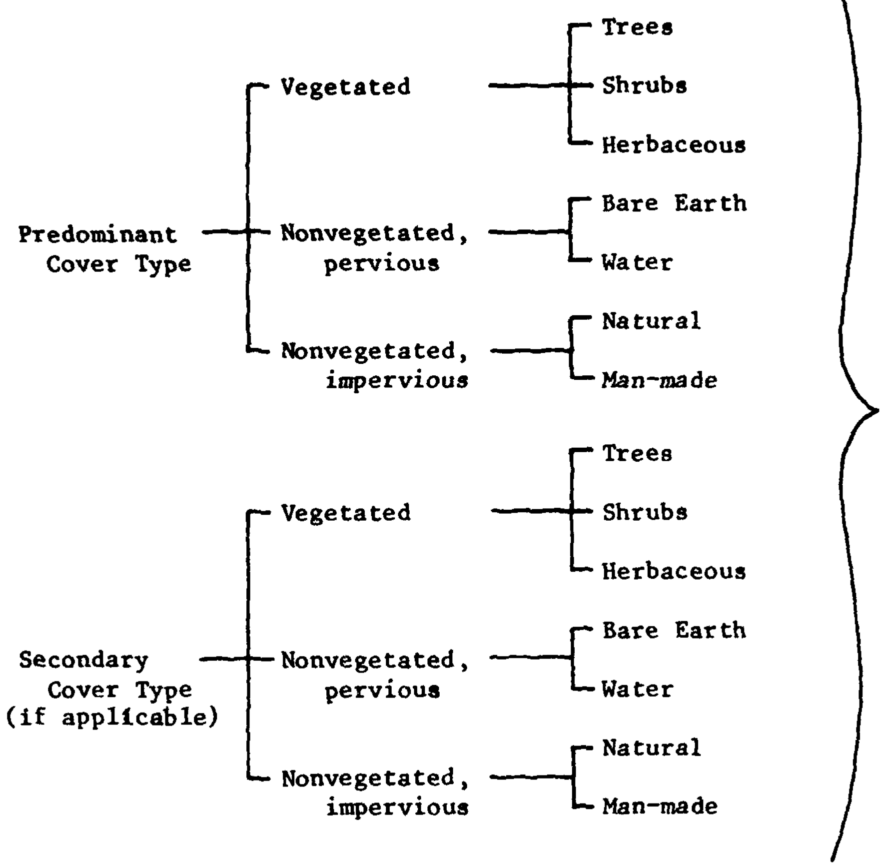


APPENDIX C

EXAMPLES OF CATEGORICAL BREAKDOWNS OF HABITAT DESCRIPTIVE PARAMETERS

Contents

IA. COVER TYPE



Could be broken down further into:

- percent coverage of cell
- size class of contiguous area of which predominant cover type is a part, e.g.:

  $<$ 1/2 acre
  1/2 to 1 acre
  1 to 2 acres
  2 to 5 acres
  5 to 10 acres
  10 to 40 acres
  40 to 100 acres
  $>$ 100 acres

  Size classes would be dependent on the nature of the variation in the study area and the natural range of the wildlife types for which conditions are being evaluated.

Note: The proportion that constitutes predominant or secondary coverage would need to be defined for each study. Secondary cover type would be a type that is fiarly significant, e.g. making up 1/4 to 1/3 of a grid cell. Cover types that are smaller would be picked up in Category II, Sgnificant Features.

IB. COVER TYPE AGE

Age of predominant cover type could be given by age category, age is taken to be number of years in that type. For example:

$\leq$ 1 year
1 to 5 years
5 to 10 years
10 to 25 years
25 to 50 years
$>$ 50 years

IC. INTERSPERSION - interspersion within predominant cover type

- Interspersion within Predominant Cover Type
  - Closed Coverage
    e.g. within contiguous area(s) of predominant cover type, more than approx. 80% coverage of the cover for which the predominant cover type is named.
  - Open Coverage
    e.g. within the contiguous area(s) of predominant cover type, less than 80% of the cover for which the predominant cover type is named.

Open Coverage could be treated as possible combinations of greater/lesser proportion of cover type mixes:

- Vegetated/Nonvegetated, pervious
  - trees/water
  - trees/bare earth
  - shrub/water
  - shrub/bare earth
  - herbaceous/water
  - herbaceous/bare earth
- Vegetated/Nonvegetated, impervious
  - trees/impervious
  - shrub/impervious
  - herbaceous/impervious
- Nonvegetated, pervious/Vegetated
  - water/trees
  - water/shrub
  - water/herbaceous
  - earth/trees
  - earth/shrub
  - earth/herbaceous
- Nonvegetated, pervious/Nonveg., imperv.
  - water/impervious
  - earth/impervious
- Nonvegetated, impervious/Vegetated
  - impervious/trees
  - impervious/shrub
  - impervious/herbaceous
- Nonvegetated, impervious/Nonveg., perv.
  - impervious/water
  - impervious/bare earth

Could be broken down further to denote actual species mix or presence of important food species

IC. INTERSPERSION (Continued) - Interspersion Between Cover Types

- Interspersion Between Cover Types
  - Spatial Density ~ no/of separate contiguous cover type areas per grid cell (either actual number or size class)
    - either/or
      - Even Texture
        - Coarse
        - Fine
      - Uneven Texture
        - Mostly Coarse
        - Mostly Fine
      - Size Class Distribution
  - Spatial Diversity ~ no. of different cover types per grid cell
    - No. of Vegetative Types
      - No. in Trees
      - No. in Shrub
      - No. in Herbaceous
    - No. of Nonvegetative Pervious
      - No. in Water
      - No. in Earth
    - No. of Nonvegetative, Imperv.
      - No. in Man-made
      - No. in Natural

ID. EDGE

- Edge
  - Absent
  - Present
    - Edge Quantity
      - either/or
        - Length of edge per grid cell (as either actual length or as length class)
          - Length of veg/veg edge
          - Length of veg/nonveg, pervious edge
          - Length of veg/nonveg, impervious
          - Length of nonveg/nonveg edge
        - Length of edge per grid cell (as either actual length or as length class <u>and</u> relative proportion or % of each type of each (e.g. veg/veg, veg/nonveg. pervious etc.)
      - Could breakdown further by species mix
    - Edge Quality of Veg/Veg Edge
      - Edge Boundary
        - Shattered
        - Abrupt
      - Edge Contrast
        - High
        - Low
        - (e.g. it tree/shrub=5, tree=4, tall shrub=3, low shrub=2, grass forb=1, then a tree/shrub edged on grass/forb would have high contrast. Water or bare could be -1, impervious could be -2. Also see next page).
      - Adjoining Block Size
        - Both large
        - Both small
        - One large/One small, and which is larger
        - Could express as size class
    - Edge Quality of Veg/Nonveg Pervious Edge
      - Edge Boundary
        - Shattered
        - Abrupt
      - Edge Contrast
        - High (e.g. same as for High and Low above)
        - Low
      - Adjoining Block Size
        - Both large
        - Both small
        - One large/One small, and which is larger
        - Could express as size class
    - Edge Quality of Veg/Nonveg Impervious Edge
      - Edge Boundary
        - Shattered
        - Abrupt
      - Edge Contrast
        - High (e.g. same as for High and Low above)
        - Low
      - Adjoining Block Size
        - Both large
        - Both small
        - One large/One small, and which is larger
        - Could express as size class

ID. EDGE (Continued)

Example of a method for characterizing edge contrast (from: Fabos, Greene, and Joyner, 1978)

Land Use Height Classes:
(for Edge Contrast Assessment)

LAND USE TYPE	CLASS
Water; bedrock	I
Bog; cranberry bog; beach;pasture; tilled land; playing field; tennis court; driving range; golf course; swimming pool; estate grounds (lawn)	II
Abandoned field; filter bed; highway; powerline; fairgrounds; playground; drive-in theater; ski area; urban vacant land; airport	III
All forest > 20' tall; orchard; abandoned orchard; stadium amusement park; urban park; apartments; houses; strip or core commercial; heavy or light industry; shopping center; truckterminal and yards, rail terminal and yards.	IV
All forests < 20' in height	V

Adjacency Edge Contrast Rating:
(for External Edge Contrast Assessment)

Rating	+1	+2	+3	+4	+5
Height Class Combination	I:I II:II III:III IV:IV V:V	I:II II:III III:IV IV:V	I:III II:IV III:V	I:IV II:V	I:V

IE. VEGETATIVE STRATA

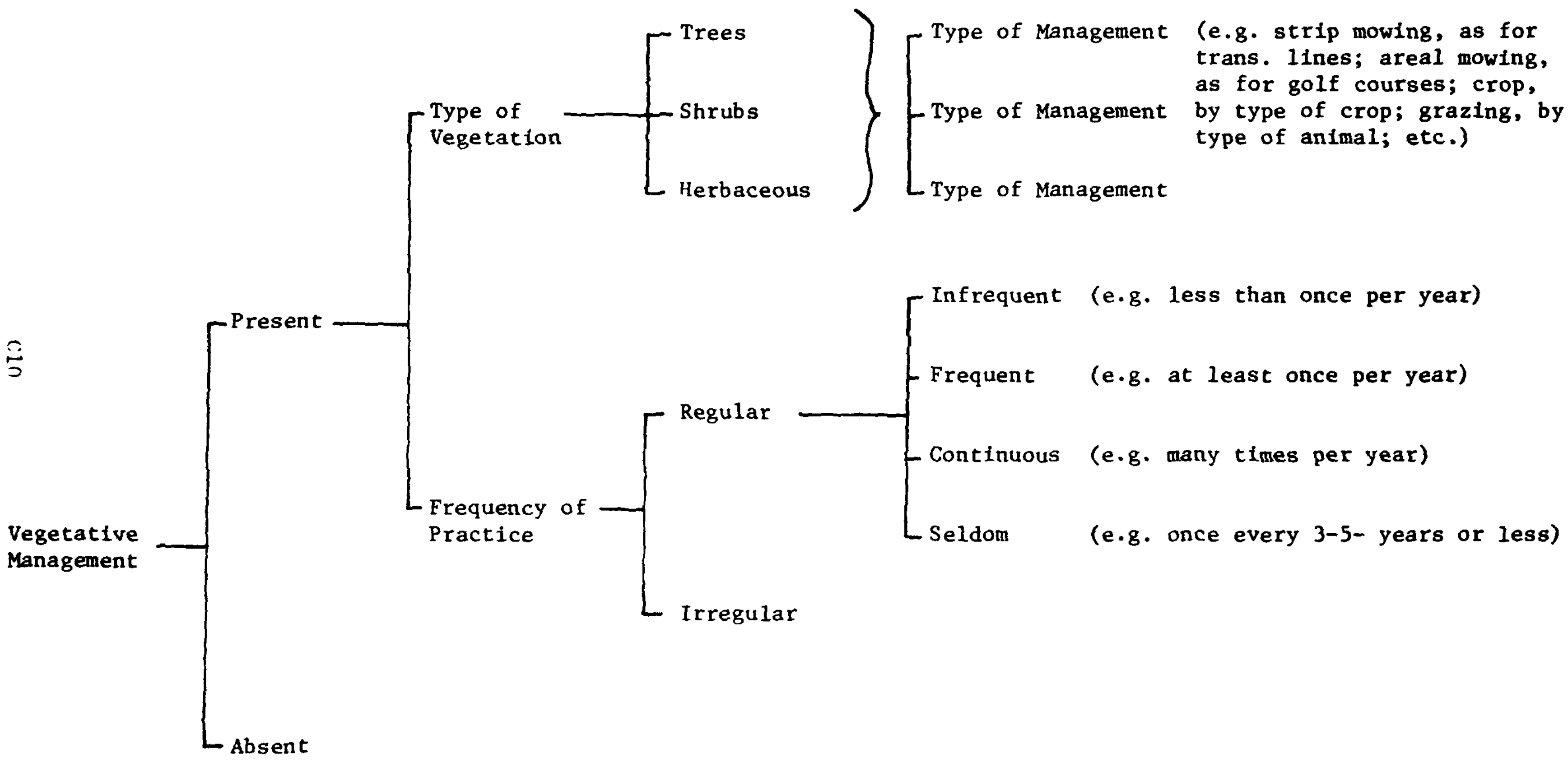
- Vegetative Strata Within Predominant Cover Type (whether or not predominant type is vegetative)
  - Overstory (primarily tree)
    - Absent
    - Present, Scattered
    - Present, Common
  - Midstory (primarily shrub)
    - Absent
    - Present, Scattered
    - Present, Common
  - Understory (primarily herb.)
    - Absent
    - Present, Scattered
    - Present, Common
- Vegetative Strata Within Secondary Cover Type
  - Overstory (primarily tree)
    - Absent
    - Present, Scattered
    - Present, Common
  - Midstory (primarily shrub)
    - Absent
    - Present, Scattered
    - Present, Common
  - Understory (primarily herb.)
    - Absent
    - Present, Scattered
    - Present, Common

Could breakdown further to denote:

-species mix

-proportional percent of presence, rather than as scattered or common

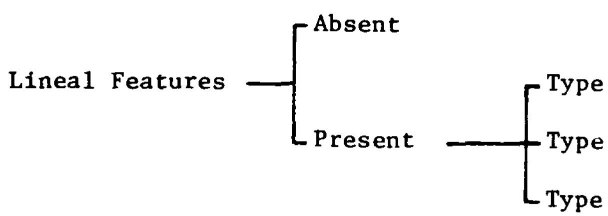
IF. VEGETATIVE MANAGEMENT PRACTICES



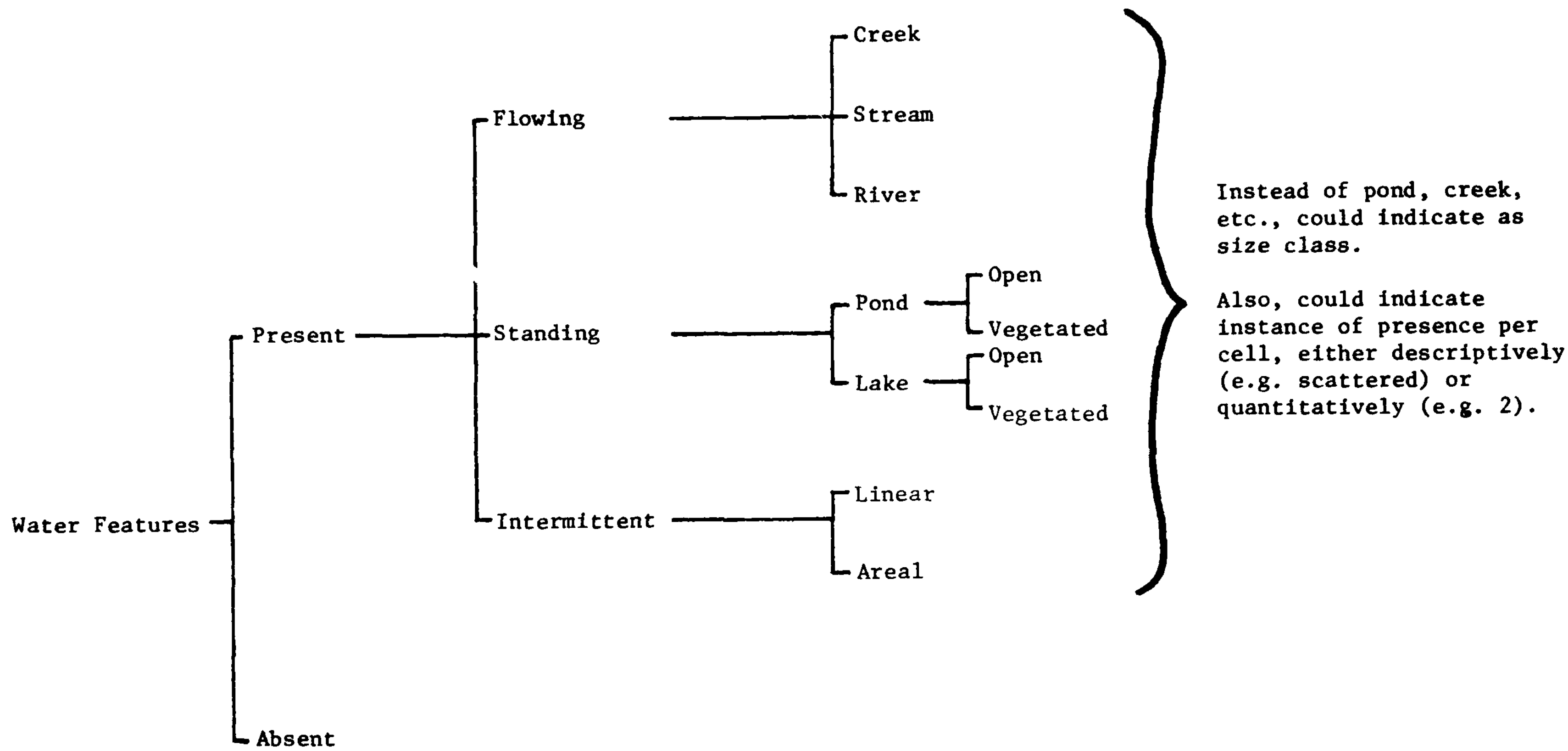
IIA. LINEAL VEGETATIVE FEATURES

Indicate of lineal vegetative features are present in the grid cell.

Examples of such features are:
- fencerows
- streamside associated growth
- transmission line cuts
- windbreaks



IIB. WATER


Water Features
Present
Absent
Flowing
Standing
Intermittent
Creek
Stream
River
Pond
Lake
Open
Vegetated
Open
Vegetated
Linear
Areal
Instead of pond, creek, etc., could indicate as size class.
Also, could indicate instance of presence per cell, either descriptively (e.g. scattered) or quantitatively (e.g. 2).

IIC. IMPERVIOUS SURFACES

- Impervious Surface Features
  - Present
    - Man-made
      - Linear - width class or nominal type (e.g. 1-lane road, 4 lanes with median)
      - Areal
        - Contiguous - size class or percent coverage of cell
        - Scattered* - size class of total coverage or number of instances with average size, or percent coverage of total cell.
    - Natural
      - Linear - width class
      - Areal
        - Contiguous - size class or percent coverage of cell
        - Scattered* - size class of total coverage, or number of instances with average size, or percent coverage of total cell.
  - Absent

*Size class for category called Scattered could be based on assumptions such as: if in high density residential, could assume that in the study area, that land use type is typically associated with 4 units of housing per acre and that means 45 percent of the acre is impervious.

IID. BARE SOIL AREAS

Bare Soil Features

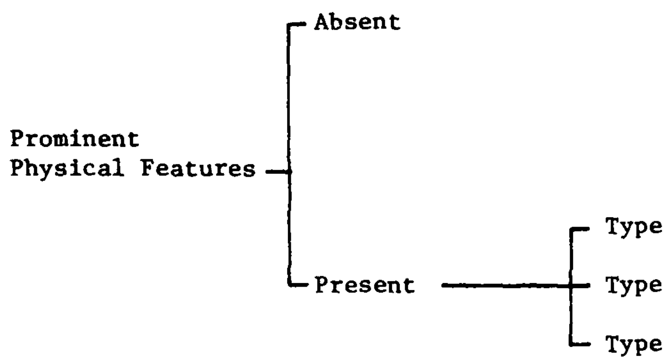
- Absent
- Present
  - Size class of coverage, or percent coverage of cell, or percent class of coverage of cell.

    Could also indicate number of instances or even size classes of number of instances.

IIE. PROMINENT PHYSICAL FEATURES

Indicate of physical features are prominent in the grid cell.

Examples of such features are:
- cliff face
- exposed rock (batholith, boulder field, etc.)
- shifting dunes
- talus slopes
- caves
- salt flats, playas



IIIA. HUMAN ACTIVITY, LINEAR/MOBILE FEATURES

- Linear/Mobile Features
  - Absent
  - Present
    - Characteristics
      - Noise
        - Human dominated
        - Machine dominated
      - Pollutant
        - Particulate
        - Toxic waste
        - Gaseous
        - Solid waste
    - Event Frequency
      - Seasonal
        - Continuous (e.g. day and night)
        - Daily (e.g. several hrs./day)
        - Frequent (e.g. once/wk or oftener
        - Infrequent
        - Seldom
      - Nonseasonal (all year)
        - Continuous
        - Daily
        - Frequent
        - Infrequent
        - Seldom
    - Event Intensity
      - No. of persons/event or size class/event
      - Noise Level
        - Category of (e.g. negligible, high, etc.)
        - Attenuation or Range (based on nature of noise and cover type of cell and adjoining cells)
      - Pollutant Level
        - Category of
        - Attenuation or Range (dispersion)

NOTE: Noise levels associated with types of activities are included following IIIC in order to provide some guidance.

IIIB. HUMAN ACTIVITY ASSOCIATED WITH PREDOMINANT COVER TYPE

- Areal/Stationary Activity within Predominant Cover Type
  - Absent
  - Present
    - Characteristics
      - Noise
        - Human dominated
        - Machine dominated
      - Pollutant
        - Particulate
        - Toxic waste
        - Gaseous
        - Solid waste
    - Event Frequency
      - Seasonal
        - Continuous (e.g. day and night)
        - Daily (e.g. several hrs./day)
        - Frequent (e.g. once/wk or oftener
        - Infrequent
        - Seldom
      - Nonseasonal (all year)
        - Continuous
        - Daily
        - Frequent
        - Infrequent
        - Seldom
    - Event Intensity
      - No. of persons/event or size class/event
      - Noise Level
        - Category of (e.g. negligible, high, etc.)
        - Attenuation or Range (based on nature of noise and cover type of cell and adjoining cells)
      - Pollutant Level
        - Category of
        - Attenuation or Range (dispersion)

NOTE: Noise levels associated with types of activities are included following IIIC in order to provide some guidance.

IIIC. HUMAN ACTIVITY ASSOCIATED WITH SECONDARY COVER TYPE

- Areal/Stationary Activity within Secondary Cover Type
  - Absent
  - Present
    - Characteristics
      - Noise
        - Human dominated
        - Machine dominated
      - Pollutant
        - Particulate
        - Toxic waste
        - Gaseous
        - Solid waste
    - Event Frequency
      - Seasonal
        - Continuous (e.g. day and night)
        - Daily (e.g. several hrs./day)
        - Frequent (e.g. once/wk or oftener
        - Infrequent
        - Seldom
      - Nonseasonal (all year)
        - Continuous
        - Daily
        - Frequent
        - Infrequent
        - Seldom
    - Event Intensity
      - No. of persons/event or size class/event
      - Noise Level
        - Category of (e.g. negligible, high, etc.)
        - Attenuation or Range (based on nature of noise and cover type of cell and adjoining cells)
      - Pollutant Level
        - Category of
        - Attenuation or Range (dispersion)

NOTE: Noise levels associated with types of activities are included following IIIC in order to provide some guidance.

III. HUMAN ACTIVITIES (Continued)

Examples of associations between Land Use Types and Noise Levels

1. From Fabos and Caswell (1977):

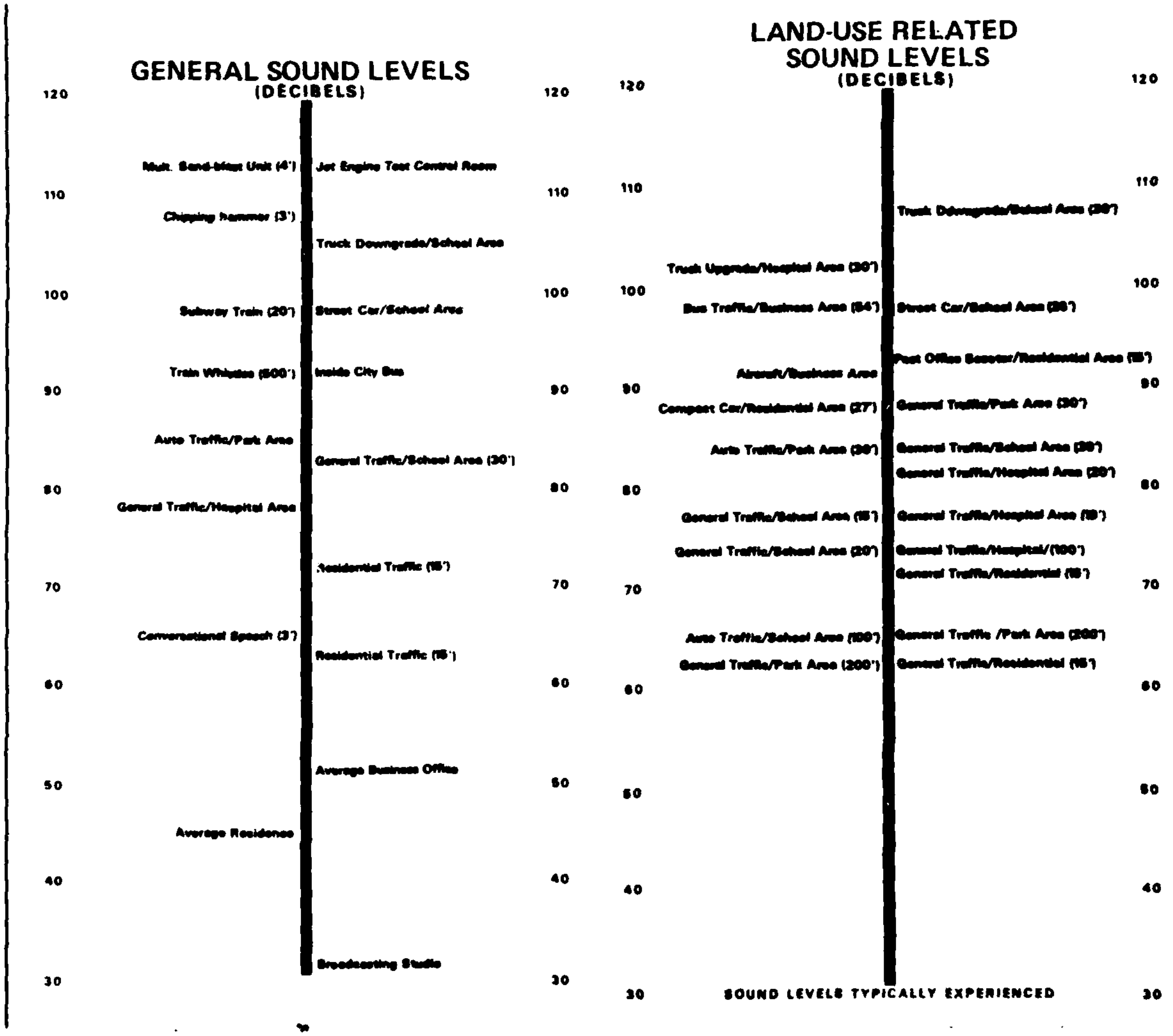
Land Use Noise Levels and Groups

Land Use Type	Noise Level (dBA)	Land Use Noise Group
Openspace**	35*	I
Tilled	40*	II
Plant Nursery	40	
Orchard	40	
Cemetary	40	
Powerline	40	
Estates	40	
Clustered Residential	45	III
Drive-in Theater	50	IV
Golf Course	50	
Town Houses	55*	V
Garden Apts.	55*	
Institutional	55	
Urban Park	55	
Ski Area	55	
Tennis Courts	55	
Lt. Industry	60*	VI
Athletic Field	65	VII
Playground	65	
Swimming Pool	65	
Shopping Center	65*	
Amusement Park	70	VIII
Agric. Fair Ground	70	
Hwy. Strip Commercial	70	
Dump	70	
Urban Core	75*	IX
Railroad	75	
Bus Terminal	75	
Heavy Industry	75	
Race Track	75	
Sand and Gravel Pit	80	X
Mining	80	
Airport	90*	XI

* Statistical noise levels from California noise measurement survey.

** Includes all undeveloped land such as wetlands, forests, and openland.

2. From U.S. Department of the Interior, National Park Service (1972):



*U.S. GOVERNMENT PRINTING OFFICE: 1982-0-394-649/331

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